

# SOIL SURVEY TILLAMOOK AREA Oregon



UNITED STATES DEPARTMENT OF AGRICULTURE  
Soil Conservation Service  
In cooperation with  
OREGON AGRICULTURAL EXPERIMENT STATION

# HOW TO USE THE SOIL SURVEY REPORT

**T**HIS SOIL SURVEY of the Tillamook Area will serve several groups of readers.

It will help farmers in planning the kind of management that will protect their soils and provide good yields; assist engineers in selecting sites for roads, buildings, ponds, and other structures; aid foresters in managing woodlands, and add to our knowledge about soils.

Soil scientists studied and described the soils, and made a map that shows the kind of soil everywhere in the Tillamook survey area. The base for the soil map is a set of photographs taken from an airplane. Fields, woods, roads, and many other landmarks can be seen on the photographs.

## Locating Soils

Use the index to map sheets to locate areas on the large map. The index is a small map of the survey area, on which numbered rectangles have been drawn to show where each sheet of the large map is located. When the correct sheet of the large map is found, it will be seen that boundaries of the soils are outlined and that there is a symbol for each kind of soil, wherever it appears on the map. Suppose, for example, an area located on the map has the symbol WeC. The legend for the detailed map shows that this symbol identifies Winema silt loam, 3 to 12 percent slopes. This soil and all others mapped in the survey area are described in the section "Descriptions of the Soils."

## Finding Information

The report has special sections for different groups of readers. All users will find information about the soils and their management in various parts of the report, depending on their particular interest.

The first section describes how soils are mapped and classified. Those interested in general soil areas will want to read the section "General Soil Map." This section tells briefly about the principal patterns of soils, where they are located, and how they differ from each other.

*Farmers and those who work with farmers* can learn about the soils in the section "Descriptions of the Soils,"

and then go to the section "Use and Management of the Soils." In this way they first identify the soils on their farms and then learn how these soils can be managed and what response can be expected. The soils are grouped by capability units; that is, groups of soils that need similar management and respond in about the same way. For example, Hebo silty clay loam, 0 to 3 percent slopes, is shown to be in capability unit IVw-2. The management needed for this soil will be found under the heading "Capability Unit IVw-2," in the section "Use and Management of the Soils." A list just ahead of the map sheets gives the name of each soil mapping unit, the symbol of the capability unit in which it has been placed, the symbol of the woodland suitability group, and a column for each showing the page where these interpretations are described.

*Soil scientists* and others interested in the nature of soils will find information about how the soils were formed and how they are classified in the section "Genesis, Classification, and Morphology of the Soils."

*Engineers and builders* will find information that will assist them in the section "Engineering Properties of the Soils."

*People who are interested in growing trees* will find woodland suitability groups of soils described in the section "Uses of Soils for Woodland."

*People not familiar with the survey area* will find useful information in the section "General Nature of the County," which discusses early history, climate, water supply, and other subjects.

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This soil survey was made as a part of the technical assistance furnished by the Soil Conservation Service to the North Tillamook and the South Tillamook Soil Conservation Districts. Help in farm planning can be obtained from the staff of the Soil Conservation Service assisting these districts. Unless otherwise indicated, all statements in the report refer to conditions in the survey area at the time the fieldwork was in progress. Fieldwork for the survey was completed in 1956.

This publication is a cooperative contribution from the Soil Conservation Service and Oregon Agricultural Experiment Station.

Cover picture: Terraces and uplands in the southern part of the Tillamook survey area. The dominant, nearly level Hebo and Chitwood soils in foreground are used mainly for hay and pasture. The Meda soils are at the lower ends of upland drainageways. Astoria soils are dominant on slopes in background, which have a cover of Douglas-fir, alder, and bigleaf maple.



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# SOIL SURVEY OF TILLAMOOK AREA, OREGON

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**T**YPICAL COASTAL TERRAIN makes up the Tillamook survey area. Along the coast is a narrow belt of level to rolling land. The shore in some places is cliffs of igneous rock and in other places it is sandy beaches and inlets. Immediately east of the coast are high, sharp ridges dissected by the valleys of narrow streams. Elevations range from sea level to about 3,500 feet on the high parts of the Oregon Coast Range. The Tillamook, Nehalem, Salmonberry, Miami, Kilchis, Wilson, Trask, and the Nestucca Rivers drain the survey area and flow into the Pacific Ocean.

The Tillamook Area covered by this report consists of 141,920 acres situated along the Pacific coast and in river valleys in the western part of Tillamook County, Oreg. It covers about one-fifth of the county land area and lies mostly west of the forests that burned in the fires of 1933, 1939, and 1945.

This soil survey report is mainly about the soils in the Tillamook Area, commonly also referred to as the Tillamook survey area. The soils in this area were surveyed in detail; those in other parts of the county referred to in this report, including some along the coast, were surveyed by reconnaissance methods. The report describes in detail the soils in the Area, their uses and

management, and their origin, constitution, and classification.

The section "General Soil Map" applies to the whole county and is based partly on the detailed soil survey and partly on spot reconnaissance surveys in the remaining four-fifths of the county. The section "General Nature of the County" provides statistics and information about the whole county.

Figure 1 shows the location of the Tillamook survey area in Oregon.

## *How Soils Are Mapped and Classified*

Soil scientists made this survey to learn what kinds of soils are in the Tillamook survey area, where they are located, and how they can be used.

They went into the survey area knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the survey area, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this report efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. The Gardiner and Knappa soils, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness,

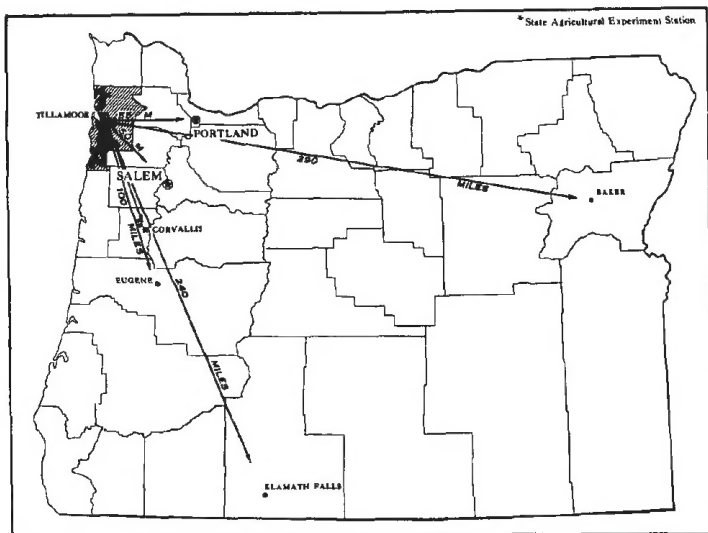


Figure 1.—Location of Tillamook survey area (shown in black) in Oregon.



or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Gardiner fine sandy loam and Knappa silt loam are examples of soil types.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Knappa silt loam, 0 to 7 percent slopes, is one of several phases of Knappa silt loam, a soil type that ranges from nearly level to gently rolling.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that greatly help in drawing boundaries accurately. The soil map in the back of this report was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas in which different kinds of soils are so intricately associated that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex or an undifferentiated unit. Ordinarily, these mapping units are named for the major soil series in them. Also, on most soil maps, areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they scarcely can be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Rock land, Tidal flats, or Riverwash, and are called land types rather than soils.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in a way that it is readily useful to different groups of readers, among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each

specified use is the method of organization commonly used in the soil survey reports. Based on the yield and practice tables and other data, the soil scientists set up trial groups and test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

## General Soil Map

During the detailed mapping of soils in the Tillamook survey area, a more generalized map was prepared for 32,640 acres of a representative part of the "Tillamook Burn," outside of the survey area. In addition, spot reconnaissance soil surveys were made in various parts in the rest of Tillamook County. These surveys, as well as the detailed soil survey, are the basis for the colored general soil map in the back of this report.

General soil areas are also called soil associations. Each kind of general soil area, or association, as a rule contains a few major soils and several minor soils, in a pattern that is characteristic although not strictly uniform.

The soils within any one association are likely to differ greatly among themselves in some properties; for example, slope, depth, or natural drainage. Thus the general map does not show the kind of soil at any particular place, but a pattern that has in it several kinds of different soils.

The general soil areas, or soil associations, are named for the major soil series in them, but as already noted, soils of other series may also be present. The major soil series in one general soil area may also be present in other areas, but in a pattern different enough to require a boundary.

The general soil map is useful to people who want a general idea of the soils, who want to compare different parts of a county, or who want to know the possible location of good-sized areas suitable for a certain kind of farming or other land use. Descriptions of the seven general soil areas, or soil associations, in Tillamook County follow.

### 1. Nehalem-Brenner-Coquille Association

*Dominantly nearly level soils, chiefly on broad stream bottoms*

This general soil area consists mainly of the Nehalem, Brenner, and Coquille soils, but the Nestucca and Gardiner soils also occur to a minor extent. These soils have formed in deep, nearly level to gently sloping sediment deposited by the main streams and their tributaries. This sediment washed from basalt and sandstone-shale bedrock in the interior uplands. These alluvial bottom lands formed by this sediment range in width from a few hundred feet to more than a mile and extend upstream for a distance of as much as 7 miles along sharply incised stream channels.

The soils in this association differ mainly in drainage, permeability, and position. Those highest above the



channels are the well-drained, moderately permeable, silty Nehalem soils. Those less elevated than the Nehalem soils are the moderately well drained and moderately permeable, inextensive Nestucca soils. Those nearest the streams are the imperfectly drained, moderately slowly permeable Brenner soils, which occupy concave slopes that are normally flooded in the rainy season.

The Coquille soils are adjacent to stream channels on tidal flats. They are poorly drained and moderately permeable and are underlain by tidal mud. The Gardiner soils are well drained and moderately rapidly permeable and are underlain by sandy alluvium. They are in positions similar to those occupied by the Nehalem soils.

Approximately one-half the acreage of tillable soil in the survey area is in this soil association. The inherent fertility of these soils is the highest of any in the Area, but many soils require drainage for maximum productivity. Originally, these soils were almost all forested. Now most of them have been cleared and are used mainly for hay and pasture. Most farmers irrigate their crops in the dry months.

## 2. Netarts Association

### *Sand hills*

This association consists of sand hills and tidal flats along the coastal plain. It is comprised mainly of the Netarts and Coquille soils. In addition, Active dune land and very small basins of the Brallier or Yaquina soils occur intermittently throughout the association.

The Netarts and Coquille soils differ mainly in texture, position, and drainage. The well-drained, sandy Netarts soils are on sand hills. They have narrow red and yellow bands, or lenses, of iron, aluminum, and organic matter in the subsoil below a depth of 12 inches. These red and yellow bands are often slightly cemented. The very poorly drained Coquille soils are on tidal flats and are underlain at a depth of more than 2 feet by blue tidal mud.

When stabilized, Active dune land soon develops the profile characteristics of the Netarts soils, but it still has hummocky surface contour. The Brallier soils are very poorly drained and have a water table at or near the surface most of the time. The imperfectly drained Yaquina soils have a high water table that fluctuates between 1 and 5 feet from the surface. This allows the organic matter to decompose and the subsoil to develop mottles and red and yellow layers of iron, aluminum, and organic matter.

Soils of this association have a limited agricultural value, but bogs on small areas of Brallier peat are highly valued for cranberries. The Netarts soils are moderately productive of timber, florist's vegetation, and shore pine, which is valued for Christmas trees. The Coquille soils are moderately productive when diked, drained, and planted to suitable pasture grasses. The most valuable vegetation on areas of Active dune land is a good cover of European beachgrass, salal, huckleberry, and shore pine that stabilizes the dunes and keeps sand from covering productive soils nearby (figs. 2 and 3).



**Figure 2.—Stabilization of sand dunes in the Netarts association.** The vegetation planted in rows is European beachgrass; that in dark patches on dunes is salal and Scotch-broom. The picket fence in foreground is a barrier that helps to stabilize the sand.

## 3. Quillayute-Knappa-Hebo Association

*Dominantly level to gently sloping, medium- to fine-textured soils on old alluvial terraces*

This association consists mainly of the Quillayute, Knappa, and Hebo soils. Small areas of the Chitwood and Ginger soils also occur. Soils of this association occupy nearly level to gentle slopes on stringers of old alluvial terraces, and areas between the alluvial bottoms and the forested or shrub- and grass-covered uplands. Small, narrow areas of this association are moderately steep.

The soils differ mainly in the amount of organic matter in the surface soil, in drainage, and in permeability. The well-drained, moderately permeable Quillayute soils occupy shrub- and grass-covered terraces. Their surface soil is black and high in organic matter. The Knappa soils also are well drained and moderately permeable, but they have a very dark brown surface layer and are medium in organic matter. The poorly drained, very slowly permeable Hebo soils are high in organic matter. The imperfectly drained, slowly permeable Ginger soils occupy the shrub- and grass-covered terraces. Their surface layer is high in organic matter. In development, the Ginger soils are between the Quillayute and Hebo soils. The imperfectly drained, slowly permeable Chitwood soils are like the Ginger soils but have a much browner surface layer.

This soil association has about 50 percent of the tillable soil in the Tillamook survey area. The inherent fertility of these soils, however, is much less than that of the soils on bottom lands.



#### 4. Winema-Neskowin Association

*Gently sloping to very steep grass- and shrub-covered soils of the uplands*

This soil association is in three small tracts. The Winema and Neskowin soils make up most of the association. Minor areas of the Brenner soils occur on narrow alluvial bottom lands. The main soils occupy low hills and foot slopes on which there is a gradual transition to the forested uplands of the Astoria-Hembre association.

The soils of the Winema-Neskowin association differ from each other in parent material, depth, and slope. The silt loam Winema soils have formed in sedimentary residuum on gentle to steep slopes. Most of the Winema soils are deep, but some of them on steep and moderately steep slopes are less than 36 inches deep over sandstone and shale. The silty clay loam Neskowin soils occur on moderately steep to very steep slopes and have formed in basalt residuum. Both the Winema and Neskowin soils have surface layers that are high in organic matter.

Most of this soil association is too steep for cultivation and is used mainly for sheep range. Farming is done only in small areas of the deep, nearly level soils adjacent to old alluvial terraces. The soils in this association are moderately productive if planted to suitable pasture grasses.

#### 5. Astoria-Hembre Association

*Gently sloping to very steep soils of the forested uplands*

Most of this soil association has steep to very steep slopes and is mountainous. Although slopes are smooth and ridgetops are rounded, steep mountainous relief dominates in the association.

The soils in this area differ in parent material, texture, depth, slope, and position. The fine-textured Astoria soils have formed in the residuum of shale and some sandstone. They are on uplands; slopes range from gentle to very steep but are dominantly steep. Most areas of these soils are deep, but moderately deep Astoria soils are on some of the very steep and the steep slopes. The medium-textured Hembre soils have formed in the residuum of basalt on uplands. They occupy gentle to very steep slopes and mainly have very steep slopes.

A small acreage in this association consists of the Meda and Gaudy soils. The medium-textured Gaudy soils occur on alluvial bottoms of narrow, deeply entrenched valleys. Slopes are gentle to nearly level. The Meda soils are moderately fine textured and occupy gravelly, alluvial fans consisting of material that washed from upland soils that had formed in the residuum of sedimentary rocks. Slopes of the Meda soils range from gentle to moderately steep.

A few isolated, nearly level to gently sloping areas have been cleared and are occasionally tilled to establish pastures of improved grasses. These cleared areas border soils on old alluvial terraces or on alluvial bottom lands that are now in cultivation.



**Figure 3.**—Vegetation on a completely stabilized sand dune. The trees are shore pine; the ground cover is European beachgrass, Scotch-broom, salal, and evergreen huckleberry.

About two-thirds of this soil association was originally forested. Douglas-fir, hemlock, Sitka spruce, and alder were the dominant trees. Many areas are still in forest, and the trees grow as fast as they do in other soil associations of the Area.

Hay and pasture are the major crops, but small grains are grown in a few places. Artificial drainage is necessary on many of the soils before they can reach maximum productivity.



## 6. Hembre-Astoria Association

*Gently sloping to very steep soils of the forested uplands*

Most of this soil association is very steep and mountainous and has sharp, angular, and broken terrain.

The soils in the association differ in parent material, texture, depth, slope, and position. The moderately fine textured Hembre soils have formed in the residuum of basalt on uplands. They occupy gentle to very steep slopes, but they are mainly on very steep slopes. Most of the Hembre soils are deep, but areas of moderately deep Hembre soils occur on steep and very steep slopes. The fine-textured Astoria soils have formed in the residuum of shale and some sandstone on uplands. Slopes range from gentle to very steep. Most Astoria soils are deep, but areas of moderately deep Astoria soils are on some of the steep and very steep slopes.

A small part of this soil association consists of the Meda and Gauldy soils. The Meda soils are moderately fine textured and occur on gravelly alluvial fans. Slopes range from gentle to moderately steep. The material in which the Gauldy soils formed washed from upland soils that had formed in the residuum of sedimentary rock. The medium-textured Gauldy soils occur on alluvial bottoms of narrow, deeply entrenched valleys. Their slopes are gentle to nearly level. Most areas of the Gauldy soils were mapped as a shallow phase.

This soil association is in trees, which are used mainly for the production of lumber.

A few isolated, nearly level to gently sloping areas have been cleared and are tilled only to establish improved pasture grasses. The cleared areas border old stream terraces or flood plains that are now in cultivation.

## 7. Hembre-Kilchis-Astoria-Trask Association <sup>1</sup>

*Strongly sloping to very steep soils of the forested uplands*

This soil association covers all of the mountainous uplands in the eastern part of Tillamook County. Hembre soils are the most extensive, but large areas of Astoria soils are also included. The Kilchis soils are in many small areas on ridgetops and among basaltic rock outcrops on precipitous slopes. Trask soils occur in narrow bands on the long interfluvial ridges. In addition, small areas of Gauldy soils are in narrow valley bottoms, and small areas of the imperfectly drained Chitwood soils are in upland slump basins among the Astoria soils.

The Astoria and Trask soils have formed in the residuum of sedimentary bedrock. The Astoria soils are dark, deep, and fine textured. The Trask soils are the shallow, shaly counterpart of the Astoria soils. The Hembre and Kilchis soils have formed in the residuum of basic igneous rock. The Hembre is a moderately deep, moderately fine textured soil with moderate amounts of gravel distributed throughout the profile. The

Kilchis is a shallow, stony, and gravelly counterpart of the Hembre.

Small areas of moderately deep Astoria soils occur in the uplands underlain by sedimentary rocks. In these areas, the windthrow in forests and the construction and drainage of road grades are very hazardous.

All soils in this association are forested, and the trees are used for lumber. These soils have high natural productivity for the native vegetation—Douglas-fir, hemlock, cedar, and spruce.

## Use and Management of the Soils

This section is in five parts. The first describes some of the practices used by farmers on soils of the survey area. The second explains how soils are grouped according to their capability and describes the capability units. The third gives estimates of yields that can be obtained from the soils under three levels of management. The fourth describes the use of soils for woodland, and the fifth part discusses the engineering properties of the soils.

### Management for Hay and Pasture

Grasses and legumes grown for pasture and forage are the main crops in the survey area. Small grains and vetch are grown only to occupy the land after permanent pastures are plowed and reseeded to improved forage plants. Small grain is grown as a cleanup crop.

Precipitation is about 100 inches a year and is enough to sustain lush pastures of grass and forests of fir, hemlock, and spruce. About half the Tillamook survey area is in forest. About 70,000 acres is tillable and is used mainly as pasture for dairy cattle, which supply milk for the production of cheese.

Unless there is a drastic change in the economics of dairying or specialty crops, this type of farming will prevail over most of the survey area. Most farms have a few apple trees and produce a few cool-weather garden crops. Holly, cranberries, and blueberries are grown commercially on a few acres.

### Clearing land

The difficulty and expense of clearing trees and stumps from bottom lands, benchlands, tidelands, and the bases of slopes have contributed much to the high price of cleared land in this survey area. Clearing used to be done through use of ax and saw, a team of horses, and dynamite. It was a slow operation, and it generally took one man nearly a lifetime to clear land enough to provide him a living. Large quantities of timber were burned in clearing land for farming.

The modern way to clear land consists of felling the trees, yarding them into large piles, and then burning them. After the trees have been burned, the stumps are blasted out with dynamite, and tractors are used to clear away the debris. This method of clearing costs about \$500 per acre. Costs depend on the size of the trees and stumps.

<sup>1</sup>The Kilchis and Trask soils were not mapped in the survey area and for this reason are not described in the section "Descriptions of the Soils." They are, however, described in the section "Descriptions of Soil Profiles."



Many large trees have been covered by soil in the clearing and leveling of land. Wherever found, these buried trees now cause much difficulty in digging drainage systems and add substantially to the cost and complications of such work.

Cleared land is smoothed and then generally is seeded to a small grain or temporarily to grass. At harvesttime the land is again plowed to remove additional roots and to smooth out stump holes in which filled dirt has settled.

### ***Irrigation***

Supplemental irrigation during the dry summer months through use of sprinkler systems is an accepted practice in the Tillamook survey area. Well-drained soils, or those that have been adequately drained artificially, respond well to sprinkler irrigation, and the application of water causes no special management problems. A high percentage of the bottom-land soils is irrigated because water is available. Irrigation of the soils on terraces and on uplands is limited by lack of available water. Water for irrigation is obtained mainly from perennial streams, although a few irrigation wells have been drilled in tideland.

According to the 1959 Census, 6,071 acres of pasture and hay in Tillamook County were irrigated by the sprinkler method.

### ***Drainage***

Because rainfall is heavy and many of the soils are in low positions and are slowly permeable, drainage is a major problem on most farms in the Tillamook survey area. Artificial drainage is necessary on the Brullier, Brenner, Coquille, Hebo, and Yaquina soils. It is helpful on the Chitwood, Ginger, and Nestucca soils.

The surface of soils can generally be drained by leveling or by constructing shallow waterways that have a slight grade and that allow excess water to flow from the soil. The subsurface of soils can be drained by installing tile drains to lower the water table.

Additional drainage information is provided in the section "Descriptions of the Capability Units."

### ***Organic matter***

The soils of the Tillamook survey area are high in organic matter, a fact that partly accounts for their stable soil structure. Organic matter also promotes the favorable infiltration and permeability of these soils. Some forested soils in the Area contain as much as 13 percent organic matter, and some soils that have formed under a cover of grasses and shrubs contain more than 20 percent. The organic matter is evidently very stable and does not decompose readily. It maintains itself at a high level, even after the soils have been cultivated for a long time. The composition of the organic matter, the pH level of less than 5.5, the rainfall of more than 90 inches per year, and the cool temperatures throughout most of the year contribute to the characteristics of the organic complex. If farmers could control the mineralization of the organic complex, they would make an important contribution to the fertility of soils in the survey area. According to present knowledge, soil amendments and fertilizers should be applied to create a soil environment that promotes bacterial activity. Plant residue should be applied only when it is

fresh, so that it can be readily broken down. The use of all barnyard manure and the maintenance of vigorously growing legumes in legume-and-grass mixtures helps to activate the organic complex and contributes to soil productivity.

Grasses have a large and finely fibrous root system that is well distributed through the upper part of the soil. Microfauna that decompose the highly carbonaceous grass roots secrete a substance that helps to improve soil structure, to bind the soil particles, and thus to control erosion.

Legumes properly inoculated with nitrogen-fixing bacteria add considerable nitrogen to the soil. When plowed under, clover and other legumes may provide several hundred pounds of nitrogen per acre to the soil.

### ***Plant nutrients***

Plants need at least 16 chemical elements for growth. They need carbon, hydrogen, oxygen, sulfur, calcium, iron, magnesium, nitrogen, phosphorus, potassium, copper, zinc, molybdenum, chlorine, boron, and manganese. They get carbon, hydrogen, and oxygen mainly from water and air. Supplies of iron, magnesium, zinc, chlorine, and manganese appear to be adequate in soils of the survey area; those of boron and sulfur are possibly deficient. Molybdenum-induced copper deficiency in animals has been recognized and is now under investigation. Calcium, nitrogen, phosphorus, and potassium are deficient in soils of the survey area, and the deficiency interferes with the growth of all cultivated crops not native in the Area.

Soils of the survey area are acid, low in base saturation, and low in calcium. Lime should be applied before soils are fertilized. The proper and timely application of lime indirectly increases the availability of nitrogen, phosphorus, and other plant nutrients that healthy plants need. Lime also helps to provide a suitable environment for the activity of soil bacteria.

Phosphorus is essential to normal plant growth and to the production of grain or fruit. Crops respond well to phosphate if they are growing in soil containing enough lime. The phosphorus-supplying ability of soils of the Tillamook survey area is low.

Soils in the Tillamook survey area are generally short of nitrogen. Plants need this element for growth and for the manufacture of proteins. When properly applied in needed amounts, nitrogen helps to balance the plant-nutrient supply. Solid and liquid barnyard manure benefit the soils, but manure does not supply enough nitrogen to allow plants to grow rapidly and to produce highest yields.

Potassium is naturally deficient in many soils in the survey area, but enough of it can be supplied through the use of solid and liquid barnyard manure.

Legume-and-grass mixtures grown for hay, silage, and pasture are the main crops in the Tillamook survey area. Soil amendments and fertilizers are important for establishing pastures of high-producing grasses and legumes and for maintaining a vigorous stand throughout the normal life of the plants.

For new seedings, lime should be applied evenly and mixed thoroughly with the surface soil. It ought to be applied well in advance of seeding, as time is needed for it to dissolve and be absorbed in the soil colloidal complex.



Legumes need phosphate fertilizers for maximum growth. Grass also responds to phosphate but will thrive on less than is required for legumes. Both legumes and grass can be given phosphate early in spring or late in fall. For new seedings, phosphate should be worked into the soil during the preparation of the seedbed, either in spring or in fall, in amounts indicated by soil tests.

Nitrogen fertilizers accelerate the growth of grasses in a mixture with legumes and reduce competition by the legumes. Good management is needed to maintain the legumes in a mixed stand that has been fertilized heavily with nitrogen.

Manure is beneficial to pastures. When decomposed, a ton of it furnishes about 10 pounds of nitrogen, 5 pounds of phosphorus, and 10 pounds of potash and improves the physical condition of the soil. Plant nutrients in manure are preserved through use of large quantities of bedding material. Manure should be kept moist but not exposed to leaching, and it should be spread as early as possible in spring. To save labor, some farmers spread manure each day. Manure that accumulates should be stored under a roof to prevent leaching of plant nutrients and should be spread early in spring.

On most dairy farms in the survey area, liquid and solid barnyard manure ordinarily supply enough potash for maximum growth of legumes and grasses. However, commercial potash is used to establish legumes and grasses on newly cleared soil or to obtain extremely high yields of these crops.

The use of soil amendments and fertilizers on legumes and grasses provides the following benefits:

1. Improves the yields of forage through better utilization of spring and fall soil moisture and extends the grazing season during these seasons.
2. Helps to maintain a vigorous stand when applied in summer and accelerates the growth of grasses so they can compete with legumes.
3. Improves the balance of growth in grasses and legumes, and reduces the hazard of bloat in grazing animals.

Research is needed to enhance the benefits obtained from the use of commercial fertilizers and lime in the Tillamook survey area. At present, soil tests provided by the Oregon Agricultural Experiment Station are a reasonable guide for the application of lime, phosphate, and potash.

### ***Establishing and managing pasture***

The establishment of pasture is expensive; consequently, a good seedbed is of primary importance. Success in establishing a good stand of improved varieties of grasses and legumes depends mainly on careful and thorough preparation of the seedbed. Tillage of the soil for the seedbed should destroy existing vegetation and leave the soil friable enough for seeding.

Eradication of weeds and weedy grasses from soil to be seeded is difficult; deep plowing and repeated disking and harrowing are necessary. In addition, the soil should be summer fallowed, or used for one or more cleanup crops, such as a grain, before seeding the perennial forage plants.

Small-seeded legumes and perennial grasses are best established on a firm, weed-free, moist seedbed. Packing

the seedbed with an improved type of roller brings the soil particles into close contact with small seeds and holds soil moisture close to the surface. This practice insures good germination of seed and helps to establish the seeded plants quickly.

Lime and fertilizer should be applied before seeding. In addition, if the legumes are to be productive and obtain nitrogen from the atmosphere, the legume seed must be inoculated with nitrogen-fixing bacteria. The culture of nitrogen-fixing bacteria suitable for the seeded plant should be used.

Clean seed and a mechanical seeder should be used for seeding grasses and legumes. This insures an even distribution of seed and a uniform depth of seeding, both of which greatly increase the chances of establishing a full, even stand that is fairly free of weeds. The soil should be kept moist, by irrigation if necessary, after seeding and during the period of germination and early rooting of the new plants.

New pastures should not be grazed during the year in which they are established. They should be mowed periodically to reduce the competition of weeds. Companion crops are generally not necessary, but if one is grown, it should be harvested as green-chopped material or early as silage.

Forage production on many pastures in the Tillamook survey area can be greatly increased if management is improved. The main practices that will increase production are rotating the grazing, applying enough fertilizer, controlling weeds, establishing improved varieties of forage plants, and preventing grazing when pastures are too wet.

Rotating the grazing of pastures improves the utilization and production of forage and prolongs the life of the forage plants. With an adequate rotation system, several pastures can be grazed for not more than 5 days at a time and there are enough pastures to allow each one a 14- to 17-day recovery time between grazing.

Continuous grazing lowers forage yields, weakens the vigor of grasses, and reduces their survival in the mixture. It also indirectly helps bentgrass, velvetgrass, and weeds to encroach and to become established in pastures.

To have pastures of high quality, the operator should apply lime before seeding, phosphate each year, and potash twice a year or at more frequent intervals if good production is desired.

The control of weeds and weedy grasses in established pastures is a constant problem. Bentgrass, velvetgrass, tussock (*Juncus* spp.), Canada thistle, dock, and tansy ragwort are the main problem weeds. Brackenfern and blackberry may also be troublesome. Mustard, buttercup, skunkcabbage, plantain, bullthistle, and dandelion are the common but easily controlled weeds.

Occasional clipping, the timely use of chemical weed killers, and periodic harrowing to scatter droppings and to level rodent mounds are good supplemental practices. These operations can result in improving the utilization of forage.

All improved pastures eventually need to be reestablished. The productive length of life of improved forage plants depends upon the species in the mixture and the degree of pasture management that has been practiced.

The soil on some farms requires drainage before pastures can be managed properly. Cattle trampling on wet soil causes compaction and damages the grass and legume plants. The resulting loss in vigor of the grasses and legumes can encourage encroachment of weeds and weedy grasses.

#### GRASSES AND LEGUMES GROWN IN SURVEY AREA

Tall fescue (*Festuca elatior* var. *arundinacea*) is a long-lived bunchgrass, well suited to the soil and climate of the area surveyed. It is high in forage production, has numerous deep roots that help the control of erosion, and, in older stands, forms a complete sod. Tall fescue is low in palatability and is best when used as the only grass in a mixture with a legume.

Orchardgrass (*Dactylis glomerata*) is well suited to the better drained soils in the surveyed area. It is a long-lived bunchgrass that is high in production of forage. It is more palatable than tall fescue. It is used in simple mixtures with legumes for pasture, silage, and hay. It responds to applications of lime.

Meadow foxtail (*Alopecurus pratensis*) is tolerant of winter and early spring submergence and is, therefore, well suited to the poorly drained or winter-flooded soils of the Tillamook survey area. It is suited to strongly acid soils. Meadow foxtail is compatible with legumes, has good palatability, and produces forage throughout its growing season. It can be seeded with a drill by mixing the seed with cracked corn.

Reed canarygrass (*Phalaris arundinacea*) is a long-lived, sod-forming grass that is tolerant of prolonged submergence in cool weather. It is palatable in the early stages of growth and regrowth. It will not stand continuous close grazing.

Perennial ryegrass (*Lolium perenne*) is a fast-growing, short-lived perennial that is well suited to the soil and climate of the area surveyed. It is highly palatable but may be lower in production of forage than orchardgrass or tall fescue. Perennial ryegrass tends to be partially dormant in summer.

New Zealand white clover (*Trifolium repens*) is a long-lived, low-growing legume. It is robust, has large leaves, and is high in forage production. It is greatly superior to the common white clover and resembles ladino clover in size and appearance. It differs from ladino in that it is much more resistant to slugs because the plant is believed to contain small amounts of hydrocyanic acid, which repels slugs. New Zealand white clover responds to lime when grown on soils with a low pH.

Common white clover (*Trifolium repens*) produces less forage than New Zealand white clover and will grow under less favorable conditions, so far as lime, soil moisture, and fertility are concerned. It is primarily a pasture plant.

Ladino clover is a rank-growing variety of white clover that is severely damaged by slugs. Because of its resistance to slugs, New Zealand white clover has replaced ladino clover in the Tillamook survey area.

Big trefoil (*Lobus major*) is a long-lived, rhizomatous legume suited to wet, poorly drained soils. It is tolerant of brackish overflow water and can survive weeks of submergence. Big trefoil grows under a wide range of soil pH; it can tolerate soils with a pH of less than 5.5 better than most legumes.

Subterranean clover (*Trifolium subterraneum*) is an excellent self-perpetuating, winter-active annual legume. It germinates from seed each fall, grows slowly throughout the winter, and grows most rapidly in spring. It sets an abundant crop of seed and dies early in summer. Subterranean clover is primarily a pasture plant. It responds to lime and fertilizer.

Alsike clover (*Trifolium hybridum*) is a rapid-developing, short-lived perennial that usually behaves like a biennial. It is tolerant of low, wet soils and of those that are acid and low in fertility.

Red clover (*Trifolium pratense*) is a short-lived, productive, perennial legume. It is best suited to well-drained soils. In the survey area, it responds to lime and fertilizer.

### Capability Groups of Soils<sup>2</sup>

The capability classification is a grouping that shows, in a general way, how suitable soils are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system, the soils are grouped at three levels, the capability class, subclass, and unit. The eight capability classes are designated by Roman numerals I through VIII. In Class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In Class VIII are soils and landforms so rough, shallow, or otherwise limited that they cannot be used to produce worthwhile yields of crops, forage, or wood products. There are no Class V soils in the Tillamook survey area.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be as many as four subclasses. The subclass is indicated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* means that water in or on the soil will interfere with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, sandy, or gravelly or has a claypan; and *c* indicates that the chief limitation is climate.

Within the subclasses are the capability units, groups of soils similar enough to be suited to the same crops and pasture plants, to require the same type of management, and to have similar responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally identified by numbers assigned locally, for example, IIe-1 or IIIe-1.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their natural limitations; but without consideration of major and generally expensive landforming treatments that would change the slope, depth, or other characteristics of the soil; and without consideration of possible but unlikely major reclamation projects.

<sup>2</sup> CARL SCHMADEKE, work unit conservationist, north Tillamook Soil Conservation District, assisted in writing this section.

Seven classes in the capability system and the subclasses and units in the Tillamook survey area are described in the list that follows. There are no soils in capability class V in the Tillamook survey area.

**Class I.**—Soils that have few limitations that restrict their use.

Capability unit I-1.—Very deep, well-drained, and moderately permeable soil.

**Class II.**—Soils that have slight limitations that reduce the choice of plants and require moderate conservation treatment.

Subclass IIe.—Soils subject to moderate erosion if they are not protected.

Capability unit IIe-1.—Very deep, well-drained, nearly level to gently sloping soils on terraces.

Subclass IIw.—Soils that have moderate limitations because of excess water.

Capability unit IIw-1.—Deep, imperfectly drained soils on nearly level to gently sloping terraces.

Capability units IIw-2.—Deep, moderately well drained soils on nearly level flood plains.

Subclass IIs.—Soils that have moderate limitations of available moisture-holding capacity because of soil texture.

Capability unit IIs-1.—Sandy, gravelly, well-drained and somewhat excessively drained, nearly level to gently sloping soils on flood plains.

**Class III.**—Soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both.

Subclass IIIe.—Soils subject to severe erosion if they are cultivated and not protected.

Capability unit IIIe-1.—Deep and very deep, well-drained soils on gently to strongly sloping terraces, fans, and uplands.

Subclass IIIw.—Soils that have severe limitations because of excess water.

Capability unit IIIw-1.—Deep, poorly drained soil on nearly level flood plains; very slow runoff.

Capability unit IIIw-2.—Deep, imperfectly drained, slowly permeable soil on strongly sloping old terraces.

Capability unit IIIw-3.—Sandy, very rapidly permeable, imperfectly drained soil on nearly level to gently sloping coastal plains.

**Class IV.**—Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVe.—Soils subject to very severe erosion if they are cultivated and not protected.

Capability unit IVe-1.—Deep to moderately deep, well-drained soils on moderately steep fans and uplands.

Capability unit IVe-2.—Deep, well-drained, sandy soil on gently sloping flood plains subject to overwash; moderately rapidly permeable.

Subclass IVw.—Soils that have very severe limitations for cultivation, because of excess water.

Capability unit IVw-1.—Deep, poorly drained soils on nearly level flood plains subject to tidal overwash.

Capability unit IVw-2.—Poorly drained, very slowly permeable soil on nearly level fans, foot slopes, or old terraces.

Capability unit IVw-3.—Deep, very poorly drained, organic soil in swales along flood plains and tidelands; very slow runoff.

**Class VI.**—Soils that have severe limitations that make them generally unsuitable for cultivation and that limit their use to pasture or range, woodland, or wildlife food and cover.

Subclass VIe.—Soils severely limited, chiefly by risk of erosion if the protective cover is not maintained.

Capability unit VIe-1.—Deep to moderately deep, well-drained soils on rolling, forested, sedimentary uplands; puddle when compacted after long wet periods.

Capability unit VIe-2.—Deep to moderately deep, well-drained soils on steep, forested, basaltic uplands.

Capability unit VIe-3.—Deep to moderately deep, well-drained soils on rolling natural grass-covered uplands.

Subclass VIs.—Soils generally unsuitable for cultivation and limited for other uses by their moisture-holding capacity, stones, or other features.

Capability unit VIs-1.—Shallow, somewhat excessively drained, rapidly permeable soils on nearly level to gently sloping flood plains.

**Class VII.**—Soils that have very severe limitations that make them unsuitable for cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Subclass VIIe.—Soils very severely limited, chiefly by risk of erosion if protective cover is not maintained.

Capability unit VIIe-1.—Deep to moderately deep, very steep, well-drained soils on forested, sedimentary uplands; puddle if compacted after long wet periods.

Capability unit VIIe-2.—Deep to moderately deep, very steep, well-drained soils on forested, basaltic uplands.

Capability unit VIIe-3.—Moderately deep, very steep, well-drained soil on natural grass-covered uplands.

Capability unit VIIe-4.—Deep, coarse, sandy, well-drained soils on steep to strongly sloping dune areas.

**Class VIII.**—Soils and landforms that have limitations that preclude their use, without major reclamation, for commercial production of plants; and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

Subclass VIIIE.—Soils for which agricultural use is completely restricted by risk of erosion.

Capability unit VIIIE-1.—Active dune land.

Subclass VIIIW.—Extremely wet or marshy land.

Capability unit VIIIW-1.—Tidal flats.

Subclass VIIIS.—Rock or soil material that has little potential for the production of vegetation.

Capability unit VIIIS-1.—Riverwash, Rock land, and Made land.



**Descriptions of the capability units****CAPABILITY UNIT I-1**

The soil of capability unit I-1 is on nearly level flood plains adjacent to present streams. In places the surface is irregular because of old stream channels, mounds, and depressions. The soil is very deep, well drained, and moderately permeable. It has an available water-holding capacity of approximately 2.5 inches per foot of soil. Although the soil is strongly acid, it is the best acid soil and the most fertile soil in the Tillamook survey area. The erosion hazard is slight. The soil in this capability unit is:

Nehalem silt loam, 0 to 3 percent slopes.

All climatically adapted crops requiring good soil drainage grow well on this soil. Suitable for this soil are row and field crops, specialty crops, nursery and greenhouse crops, and mixtures of grasses and legumes for pasture, hay, and silage.

A standard rotation consists of soil-depleting crops three-fourths of the time and soil-conserving crops the rest of the time. The soil in this capability unit is now mainly under a permanent cover of grasses and legumes that is used for pasture, hay, or silage. The soil can be used much more intensively than it is.

Good stands of grasses and legumes of high quality can be established and maintained by applying moderate amounts of lime, phosphate, and nitrogen. Suitable grasses are tall fescue, orchardgrass, and ryegrass; suitable legumes are red clover and white clover.

Most areas of this soil can be irrigated by sprinklers with water obtained from adjacent rivers and streams. Irrigation is seldom needed except late in summer and early in fall. The interval between irrigations is about 12 to 14 days and can be determined by frequent checks of moisture in the field.

Streambank erosion is a problem in many places and can be prevented by constructing rock riprap, planting willows, or by use of other approved methods.

**CAPABILITY UNIT IIe-1**

The soils of capability unit IIe-1 are on nearly level to gently sloping terraces and are elevated as much as 40 feet from the flood plain. They are very deep, are well drained, and have moderately permeable subsoil. They can hold about 2 inches of available moisture per foot of soil. The soils are medium to very high in organic matter and are very strongly acid. Natural fertility is moderately low to medium. The erosion hazard is slight. Soils in this capability unit are:

Knappa silt loam, 0 to 7 percent slopes.

Quillayute silt loam, 0 to 7 percent slopes.

Row crops, cereal crops, and mixtures of grasses and legumes, which are adapted to the climate and require good soil drainage, grow well on these soils.

A standard crop rotation consists of soil-depleting crops one-half of the time and soil-conserving crops the rest of the time. These soils are mainly in a permanent cover of grasses and legumes used as pasture, or harvested for hay or silage. The soils can be used more intensively than they are.

A good stand of high-quality grasses and legumes can be established and maintained by applying nitrogen, lime,

and phosphate in large amounts; potash should be applied if soil tests indicate a need for it. Suitable grasses are tall fescue and orchardgrass; suitable legumes are white clover, red clover, and subterranean clover.

Winter cover crops are needed to protect the soils during long wet periods. Tillage across the slope protects bare fields from erosion. Diversion terraces with sod waterways may be needed in places to protect these soils from runoff flowing to them from the adjacent uplands.

Pasture management consists of properly preparing seedbeds, rotating the grazing, harrowing, clipping, and controlling weeds. Livestock should be kept off these soils when grass is dormant in winter to avoid compacting the soil and retarding plant growth in spring. Fall seedings in pasture should be made early enough to provide a protective winter cover.

Only a small part of these soils is irrigated because the source of water is too far away. A few irrigation wells have been drilled. The interval between irrigations with sprinklers ranges from 8 to 10 days. The exact interval can be determined by frequently checking the soil moisture at a depth of 12 to 15 inches in the field.

Spruce and hemlock forests are on small areas of these soils.

**CAPABILITY UNIT IIW-1**

The soils of this capability unit are in swalelike positions on nearly level to gently sloping terraces, and are as much as 40 feet above the flood plains. They are moderately deep, are imperfectly drained, and have a fine-textured, slowly permeable subsoil. They have an available water-holding capacity of 2 inches per foot of soil. Roots can penetrate moderately deep but are restricted by imperfect drainage and silty clay subsoil. The soils are moderately low to medium in fertility, very strongly acid, and medium to very high in organic matter. The erosion hazard is slight. Soils in this capability unit are:

Chitwood silt loam, 0 to 7 percent slopes.

Ginger silt loam, 0 to 7 percent slopes.

All climatically adapted crops that can tolerate a restricted root zone and long periods of wetness grow well on these soils. Most of these soils are not drained and are used for shallow-rooted grasses and legumes and for silage crops to feed dairy cattle. Yields of crops are only fair.

These soils respond well to artificial drainage. When drained, they are suitable for row crops and other crops. The standard crop rotation for properly drained soils consists of growing soil-depleting crops about one-half of the time and soil-conserving crops the rest of the time. Drainage allows the use of the better, deeper rooted varieties of grasses and legumes. In addition, plants in drained soil start growing earlier in spring and continue to grow later in fall.

If the soil is properly drained, a good stand of high-quality grasses and legumes can be established and maintained by applying very large amounts of lime, phosphate, and nitrogen. Potash should be applied if soil tests show the need for it. Suitable grasses are tall fescue and orchardgrass; suitable legumes are red clover, subterranean clover, and white clover.

Most areas of these soils are in a permanent cover of grasses and legumes used as pasture, or harvested for hay or silage. When drained, the soils can be used more intensively than this. If cultivated, they should be protected from erosion through use of winter cover crops and cross-slope tillage. Runoff from higher lying areas should be diverted to safe channels.

The soils can generally be drained by a single interceptor tile drain or by an open ditch. The depth of the drainage system depends on the depth to the water-bearing layer. This depth can be determined by soil borings in the field. Additional lateral drains may be needed, in some places. Tile lines should have joints properly blinded.

Only a small acreage of these soils is irrigated, as they are too far from streams. A few irrigation wells have been drilled. Pastures are usually short late in summer and in fall unless they are irrigated. Water applied through sprinklers is needed every 10 to 12 days, depending on the extent to which the soil has been drained. The exact interval between irrigations can be determined by frequent checks of soil moisture in the field.

Pasture management on these soils includes properly preparing the seedbed, rotating the grazing, harrowing, clipping, and controlling weeds. Livestock should not be grazed when grass is dormant in winter. If grazed at this time, they compact the soil and retard plant growth in the spring.

Small areas of these soils are forested with spruce and hemlock.

#### CAPABILITY UNIT IIW-2

The soil in this capability unit is on nearly level flood plains. It commonly occupies the outer parts of the flood plain adjacent to higher terraces. It is deep, is moderately well drained, and has a moderately permeable subsoil. The soil is moderately high in fertility and can hold about 2 inches of available moisture per foot of soil. There is a slight hazard of erosion caused by occasional overwash of floodwater. The soil in this capability unit is:

Nestucca silt loam.

Climatically adapted crops that can tolerate a restricted root zone and long periods of wetness grow well on this soil under natural drainage conditions. If the soil has been drained artificially, it is suitable for all climatically adapted crops. A standard crop rotation on drained soil consists of soil-depleting crops one-half the time and soil-conserving crops the rest of the time. Nearly all areas of this soil are in a permanent cover of grasses and legumes used as pasture, or harvested for hay or silage.

After the soil has been drained, it can be used more intensively. Artificial drainage allows the use of the better, deeper rooted grasses and legumes. In addition, it allows plants to start growing earlier in spring and to continue growing later in the fall. After drainage, the soil is then especially well suited to pasture and hay. A good stand of high-quality grasses and legumes can be established and maintained by applying lime, phosphorus, and nitrogen in moderate amounts. Suitable grasses are tall fescue, orchardgrass, and ryegrass; suitable legumes are red clover and white clover.

Minor leveling and the use of graded, shallow waterways improve surface drainage. Subsurface drainage to lower the water table can be obtained through use of tile drains. In many places draining the associated Brenner soils reduces the need for draining the Nestucca soil.

Management of pasture consists of properly preparing seedbeds, rotating the grazing, harrowing, clipping, and controlling weeds. Livestock should not be allowed to graze when the soil is wet for long periods. If grazed on wet soil, they compact the soil and retard the growth of pasture plants in spring.

Irrigation is seldom needed except late in summer or early in fall following a long period of dry weather. Irrigation water is readily available for Nestucca silt loam; so most areas are irrigated. The interval between irrigations should be about 12 to 14 days, depending on soil drainage. The exact interval between irrigations and the amount of water to supply should be determined by checking the soil moisture at depths of 12 to 18 inches in the field.

A winter cover of vegetation is essential to prevent erosion if the soil is flooded. Mixtures of grasses and legumes should be planted early enough to grow and to provide protection in winter.

#### CAPABILITY UNIT IIS-1

The soils in this capability unit occur on flood plains near streams. They are deep to moderately deep, are well drained to somewhat excessively drained, and have a gravelly and coarse-textured subsoil. The surface is irregular and is cut by old stream channels and depressions. Permeability of the subsoil is rapid to moderately rapid. The available water-holding capacity is approximately 1.0 to 1.5 inches per foot of soil. The soil is medium to moderately high in fertility and is strongly acid. The hazard of erosion is slight. The soils in this capability unit are:

Gardiner fine sandy loam, 0 to 3 percent slopes.

Gauldy loam, 0 to 7 percent slopes.

Row crops, cereal crops, mixtures of grasses and legumes, and other crops adapted to the climate and requiring good soil drainage grow well on these soils. A standard crop rotation consists of soil-depleting crops one-half the time and soil-conserving crops the rest of the time. Most areas of these soils are now under a permanent cover of grasses and legumes harvested for pasture, hay, or silage. The soils are capable of more intensive use.

Good stands of high-quality grasses and legumes can be established and maintained if moderate quantities of lime and large quantities of phosphate and nitrogen are applied. Potash should be applied if soil tests show a need for it. Suitable grasses are tall fescue and orchardgrass; suitable legumes are subterranean clover, red clover, and white clover.

Crops on these soils require irrigation. Water is readily available from adjacent rivers and streams. Irrigations are needed about every 8 days, but field checks are needed to determine the frequency and the rate of applying water. The soils in this capability unit require smaller and more frequent applications of water than do finer textured soils.

Pasture should be seeded early in spring after high water stages have passed. Successful pasture man-

agement consists of properly preparing the seedbed, rotating the grazing, harrowing, clipping, and controlling weeds. Livestock should not be allowed to graze when grass is dormant or before the root system of young plants is established. A winter cover crop is essential in preventing soil erosion.

#### CAPABILITY UNIT IIIA-1

The soils of this capability unit are on old terraces, escarpments of terraces, alluvial fans, and uplands. They are well drained, are moderately permeable, and can hold approximately 1.5 to 2.5 inches of available water per foot of soil. They are very strongly acid, are medium to moderately low in fertility, and are susceptible to erosion. The Quillayute and Winema soils are very high in organic matter. The soils of this capability unit are:

- Astoria silt loam, 3 to 12 percent slopes.
- Hembre silt loam, 3 to 12 percent slopes.
- Knappa silt loam, 7 to 12 percent slopes.
- Knappa silt loam, moderately deep, 0 to 12 percent slopes.
- Meda gravelly loam, 3 to 12 percent slopes.
- Quillayute silt loam, moderately deep, 0 to 12 percent slopes.
- Winema silt loam, 3 to 12 percent slopes.

Cereal crops, mixtures of grasses and legumes, and other climatically adapted crops requiring good soil drainage grow well on these soils. A standard crop rotation consists of soil-depleting crops one-fourth of the time and soil-conserving crops the rest of the time. Most areas of these soils are in a permanent cover of grasses and legumes used for pasture, hay, or silage.

A good stand of high-quality grasses and legumes can be established and maintained by applying very large quantities of lime, phosphate, and nitrogen. Potash should be applied if soil tests show a need for it. Suitable grasses are tall fescue, orchardgrass, and ryegrass; suitable legumes are red clover and white clover.

A winter cover crop is needed to protect the soil during long wet periods. Cross-slope tillage is needed to prevent erosion when the soil is exposed. Fall pasture seedings should be made early enough to allow plants to grow and provide winter cover. All crop residue should be left on the surface or worked lightly into it. In places diversion terraces with sod waterways may be needed to protect these soils from runoff from adjacent uplands.

Pasture management on these soils consists of properly preparing seedbeds, rotating the grazing, harrowing, clipping, and controlling weeds. Livestock should not be allowed to graze in winter, as they compact the soil and retard forage growth in spring.

Only a small acreage of these soils is irrigated because water is not available. However, a few irrigation wells have been drilled. Water applied through a sprinkler system is needed at intervals of 8 to 10 days. The exact interval can be determined by frequently checking soil moisture at a depth of 12 to 15 inches in the field.

Small areas of these soils are in forests of spruce, hemlock, and Douglas-fir.

#### CAPABILITY UNIT IIIV-1

The soil of this capability unit is in alluvium, and it occupies nearly level flood plains or swalelike positions adjacent to streams or adjacent to terraces at the outer edge of the flood plains. It is poorly drained, is moder-

ately slowly permeable, and can hold about 1.75 inches of available moisture per foot of soil. Runoff is very slow. A high water table and silty clay subsoil restrict root penetration to a moderate depth. This soil is strongly acid and is medium in fertility. The hazard of erosion is none to slight. The soil of this capability unit is:

#### Brenner silt loam.

Climatically adapted crops that can tolerate long periods of wetness and a restricted root zone grow well in this soil under natural drainage conditions. After adequate drainage has been installed, the soil is suited to some row crops, to cereal crops, to mixtures of grasses and legumes, and to other crops adapted to the climate.

A standard rotation for properly drained soil consists of growing soil-depleting crops one-fourth of the time and soil-conserving crops the rest of the time. Most areas of Brenner silt loam are now in a permanent cover of grasses and legumes used as pasture, or harvested for hay or silage. The soil is capable of more intensive use than it now gets. If the soil is drained, farmers can grow the higher producing, deeper rooted grasses and legumes. Also, plants start growing earlier in spring on drained areas and continue growing later in fall.

A good stand of high-quality grasses and legumes can be established and maintained by applying moderate amounts of lime and large amounts of nitrogen and phosphate. Potash should be applied if soil tests indicate the need of it. Suitable grasses are tall fescue and meadow foxtail; suitable legumes are big trefoil, alsike clover, and white clover.

Winter cover crops are needed to protect this soil when it is overwashed by floods.

The soil can generally be drained by a single interceptor tile drain or by an open ditch with suitable outlets. The depth of the drainage system in the soil depends on the depth to the water-bearing layer and on the topographic position of outlets.

Pasture management consists of properly preparing seedbeds, rotating the grazing, harrowing, clipping, and controlling weeds. Livestock should not be allowed to graze during long wet periods; they compact the wet soil and retard plant growth.

Crops grown on adequately drained soil need a limited amount of irrigation during long dry periods. Supplies of irrigation water are readily available. Water applied through sprinklers is needed every 12 to 14 days. The exact interval can be determined by frequently checking soil moisture at a depth of 12 to 15 inches in the field.

Small areas of this soil are forested with spruce and hemlock.

#### CAPABILITY UNIT IIIV-2

The soil of this capability unit is on strongly sloping old terraces in concave positions that are as much as 40 feet above the flood plain. It is deep, imperfectly drained, and slowly permeable. It can hold about 1.75 inches of available moisture per foot of soil. Fertility is medium, acidity very strong, and the hazard of erosion slight. The soil in this capability unit is:

#### Chitwood silt loam, 7 to 12 percent slopes.

All climatically adapted crops that can tolerate a restricted root zone and long periods of wetness grow well on this soil under natural drainage. Under these condi-



tions, shallow-rooted grasses and legumes and cereal crops can be grown, but yields are only fair.

This soil responds well to artificial drainage and is then suitable for various cereal crops and improved grasses and legumes. Drainage allows plants to start growing earlier in spring and to continue growing later in fall. The standard crop rotation for properly drained soil consists of soil-depleting crops one-fourth of the time and soil-conserving crops the rest of the time.

If the soil is properly drained, good stands of high-quality grasses and legumes can be established and maintained by applying very large quantities of lime, phosphate, and nitrogen. Suitable grasses are tall fescue and orchardgrass; suitable legumes are red clover, subterranean clover, and white clover.

Most areas of this soil are now in a permanent cover of grasses and legumes used as pasture, or harvested for hay or silage. When drained, the soil can be used more intensively. If cultivated, the soil should be protected from erosion through use of winter cover crops and cross-slope tillage, which reduce the amount and velocity of runoff. Water flowing to this soil from higher areas should be diverted into safe waterways.

This soil can generally be drained by an interceptor tile drain or by an open ditch. The depth of the system in the soil depends on the depth to the water-bearing layer. The depth to this layer can be determined by borings in the field. Lateral drains may be needed in some places. Tile lines should have joints properly blinded.

Only a very small acreage of this soil is irrigated, as water is generally not available. Few irrigation wells have been drilled. Unless irrigated, pastures are usually short late in summer and fall. Where enough water is available, irrigations by sprinkler should occur at intervals of 10 to 12 days, depending on the extent to which the soil has been drained. The exact interval between irrigations can be determined by frequently checking soil moisture in the fields.

Pasture management on this soil consists of properly preparing seedbeds, rotating the grazing, harrowing, clipping, and controlling weeds. Livestock should not be allowed to graze during winter or when ground is saturated, as they compact the wet soil and retard the growth of plants.

This soil supports forests of Douglas-fir, Sitka spruce, western hemlock, western redcedar, and red alder.

#### CAPABILITY UNIT IIIW-3

The soil of this capability unit is in basinlike depressions among sand dunes on nearly level and gentle sloping coastal plains. It is a very rapidly permeable, imperfectly drained soil with a coarse sandy subsoil. The available water-holding capacity is less than 1 inch of water per foot of soil. A high water table limits root penetration to a moderate depth. The soil is low in fertility and is very strongly acid. It is subject to moderate wind erosion during the dry season of the year. The soil in this capability unit is:

Yaquina loamy fine sand, 0 to 3 percent slopes.

The use of this soil is restricted by low fertility and a high water table. Only blueberries, grasses, and legumes can be grown under these conditions. Yields of grasses and legumes are fair.

Proper soil drainage allows the farmer to grow the better producing, deeper rooted grasses and legumes. In addition, it allows plants to start growing earlier in spring and to continue growing later in fall. The standard crop rotation on properly drained soil consists of soil-depleting crops one-fourth of the time and soil-conserving crops the rest of the time.

If the soil is properly drained, good stands of high-quality grasses and legumes can be established and maintained by applying very large quantities of lime, nitrogen, phosphate, and potash. Suitable legumes are big trefoil and white clover; a suitable grass is tall fescue.

Most areas of this soil are now in a permanent cover of grasses and legumes that are used as pasture, or are harvested for hay or silage. When properly drained and fertilized, this soil can be used more intensively. If cultivated, the soil should be protected from wind erosion through use of a cover crop or a covering of crop residue. Also, crop residues should be used to maintain and increase the amount of organic matter in this soil.

The soil can generally be drained by use of tile or an open ditch. Joints in tile should be properly blinded to keep out sand. The banks of open ditches should have 2:1 slopes and be stabilized by a cover of vegetation or other material to prevent erosion.

Some areas of this soil are successfully irrigated with water obtained from wells. Pastures are usually short late in summer and in fall unless they are irrigated. The interval between irrigations by sprinklers is about every 8 days or less, depending on the extent to which the soil has been drained. The exact interval can be determined by frequently checking soil moisture in the field.

Pasture management consists of properly preparing seedbeds, rotating the grazing, harrowing, clipping, and controlling weeds. Livestock should not be allowed to graze when the soil is saturated, as they compact the wet soil and trample the grass. New pasture must be well established so that livestock will not pull up the young plants.

Small areas of this soil are forested with spruce, hemlock, and shore pine.

#### CAPABILITY UNIT IVE-1

The soils of this capability unit are on moderately steep uplands and on gravelly, alluvial fans. They are well drained, have moderately permeable subsoil, and can hold about 1.75 inches of available water per foot of soil. The root zone is deep to moderately deep. The soils are subject to erosion and are moderately high to very high in organic matter. They are strongly acid to very strongly acid and are moderate to moderately low in fertility. The soils of this capability unit are:

Astoria silt loam, 12 to 20 percent slopes.

Hembre silt loam, 12 to 20 percent slopes.

Meda gravelly loam, 12 to 20 percent slopes.

Neskowin silty clay loam, 12 to 20 percent slopes.

Winema silt loam, 12 to 20 percent slopes.

Winema silt loam, moderately deep, 12 to 20 percent slopes.

Cereal crops, mixtures of grasses and legumes, and other climatically adapted crops that require only limited tillage, that provide large quantities of residue, or that have a very fibrous root system grow well on these soils.

The standard crop rotation for these soils provides for the growing of soil-conserving crops 90 percent of the time and soil-depleting crops 10 percent of the time. Most of these soils are under a permanent cover of grasses and legumes that is pastured or harvested for hay or silage.

A good, thick, stand of grasses and legumes is needed to control erosion on these soils. A good stand of high-quality grasses and legumes can be established and maintained by applying lime, phosphate, and nitrogen in very large quantities. Potash should be added if soil tests indicate a need for it. Suitable grasses are tall fescue and orchardgrass. Suitable legumes are red clover, subterranean clover, and white clover.

When cultivated, these soils need a good vegetative cover that protects them during long wet periods in winter. Fall seedings of grasses and legumes should be made in the stubble of the previous crop and early enough to allow plants to grow and form a cover for winter protection of the soil. Stubbleland should be harrowed across the slopes rather than plowed in preparation for seeding.

The clearing of natural vegetation from these soils should be done only if the surface is smoothed and provided with a cover that prevents erosion during the rainy season.

Most of these soils are not now irrigated; the supply of water in rivers is too far away, or that in local wells is too uncertain. In addition, slopes of the soils in this capability unit prevent the efficient use of sprinkler systems.

Pasture management on these soils consists of properly preparing seedbeds, rotating the grazing, harrowing, clipping, and controlling weeds. Grazing should not be allowed when the grass is dormant, and it should be restricted in long, wet periods to prevent compacting the soil and retarding plant growth in spring.

The Neskowin and Winema soils are under their natural cover of shrubs and grasses. Many areas of the other soils in this capability unit are still forested, mainly with Douglas-fir.

#### CAPABILITY UNIT IVe-2

The soils of this capability unit occur on gently sloping flood plains adjacent to streams. They are somewhat irregular, and the surface in old stream channels, mounds, and depressions has hummocky microrelief. These soils are well drained but are subject to overwash by adjacent streams. Runoff is slow. The soils are moderately rapidly permeable to moderately permeable and can hold about 1.0 to 2.25 inches of available water per foot of soil. They are strongly acid and are moderately high to high in fertility. In times of overwash, the soils are susceptible to erosion. The soils in this capability unit are:

Gardiner fine sandy loam, overwashed, 3 to 7 percent slopes.  
Nehalem silt loam, overwashed, 3 to 7 percent slopes.

Cereal crops, mixtures of grasses and legumes, and other climatically adapted crops that need good drainage grow well on these soils. A standard crop rotation provides for the growing of soil-conserving crops 90 percent of the time and soil-depleting crops 10 percent of the time. Most areas of these soils are now in mixtures of grasses and legumes that are used as pasture, or are harvested for hay or silage. A good stand of high-quality grasses

and legumes can be established and maintained by applying moderate amounts of lime and large amounts of nitrogen and phosphate. Potash should be applied where soil tests show a need for it. Suitable grasses are tall fescue and orchardgrass. Suitable legumes are subterranean clover, red clover, and white clover.

The soils can be irrigated from adjacent streams and rivers. Irrigation is needed late in summer and early in fall. Water should be applied at intervals of 8 to 12 days or less, but the exact interval can be determined by frequently checking soil moisture at depths of 12 to 18 inches in the field.

Pasture management consists of properly preparing seedbeds, rotating the grazing, harrowing, clipping, and controlling weeds. Grazing should not be allowed when grass is dormant, nor until the root system of young plants is firmly established. Streambank erosion is a problem in many places and can be controlled by use of rock riprap, willow plantings, or other approved methods.

A cover of vegetation is needed to control erosion during periods of overwash. Grasses and legumes should be seeded early enough in the fall to allow young plants to grow and provide cover for winter protection of the soil.

Areas of these soils that are now in forest should stay permanently in trees, at least until the areas are no longer flooded.

#### CAPABILITY UNIT IVW-1

The soils of this capability unit occur on nearly level flood plains subject to tidal overwash. They are deep and poorly drained. Surface runoff is very slow. These soils are moderately permeable and can hold 1.75 to 2.0 inches of available water per foot of soil. They are extremely high in organic matter and have intermittent layers of peat in the profile. The root zone is restricted by a high water table. The soils are very strongly acid and are moderate in fertility. The erosion hazard is none to slight. This capability unit consists of one mapping unit:

Coquille and Brenner silt loams.

All climatically adapted crops that can tolerate a restricted root zone and long periods of wetness grow well on these soils only after drainage has been partly established. When drainage has been fully established, cereal crops and mixtures of grasses and legumes may be grown.

A standard crop rotation for properly drained areas consists of soil-conserving crops 90 percent of the time and soil-depleting crops the rest of the time. Practically all areas are now under a permanent cover of grasses and legumes that are used as pasture or are harvested for hay or silage. If well drained, the soils are capable of more intensive use.

In properly drained areas, good stands of high-quality grasses and legumes can be established and maintained by applying very large amounts of lime and large amounts of phosphate and nitrogen. Potash should be applied if soil tests indicate a need for it. Suitable legumes are big trefoil and alsike clover; a suitable grass is reed canarygrass.

Areas cultivated for the purpose of reestablishing permanent cover should be protected from overflow by a winter cover crop.



**Figure 4.**—Tide gates in a levee at stream outlet. The timber and piling hold the pipes in place. Fresh water, which accumulates in the area protected from brackish water on left side of levee, can flow freely through gate when tide is low. High tides, entering from right, forcibly close gate to keep out brackish water.

Many areas of soils in this capability unit are still undrained, but many areas have been improved through artificial drainage. For adequate drainage on these soils, dikes or levees are needed to keep out tidewater; tide gates must then be installed to dispose of accumulated fresh water (fig. 4). Open ditches are needed to drain the surface, and tile lines to drain the subsurface.

Pumps are installed at many drainage outlets to remove the accumulated water. A separate drainage system must be designed for each site.

These soils are generally not irrigated, as the water needed by crops can be obtained by regulating the height of the water table. In addition, supplies of nonbrackish water are generally not available for irrigation from the rivers or tidal sloughs. However, in the rare instances when irrigation is needed and a source of water is avail-

able, the interval between irrigations should be from 12 to 14 days.

Pasture management consists of properly preparing seedbeds, rotating the grazing, harrowing, clipping, smoothing, and controlling weeds. Grazing should not be allowed during long wet periods, since it compacts the soils and damages forage plants.

Under natural conditions, these soils have but little agricultural value. They do produce open stands of Sitka spruce.

#### CAPABILITY UNIT IVW-2

The soil in this capability unit occupies the nearly level, concave slopes of alluvial fans, foot slopes, or old terraces. It is a strongly acid, poorly drained soil that has a very slowly permeable subsoil. It can hold from 1.0 to 1.5 inches of available water per foot of soil. Runoff

is very slow; natural fertility is low. The erosion hazard is slight. The root zone is shallow because of a high water table and the clay in the subsoil. The soil in this capability unit is:

Hebo silty clay loam, 0 to 3 percent slopes.

After drainage has been established, the soil is suited to shallow-rooted grasses and legumes and to other climatically adapted crops that can tolerate long periods of wetness and a restricted root zone.

When properly drained, the soil is used in a standard crop rotation that consists of growing soil-conserving crops 90 percent of the time and soil-depleting crops 10 percent of the time. If the soil is properly drained, a good stand of grasses and legumes can be established and maintained by applying lime, phosphorus, nitrogen, and potash in quantities indicated by soil tests. Suitable grasses are meadow foxtail and tall fescue; a suitable legume is big trefoil.

Areas cultivated for the purpose of establishing grasses and legumes should be seeded early enough to allow young plants to grow and to provide cover for the soil during the rainy season.

Artificial drainage of this soil is difficult, but it can generally be accomplished by use of open ditches to remove excess water from the surface, and by use of tile drains to remove that in the subsurface. The joints of tile drains must be properly blinded. Diversion terraces that intercept water flowing from higher areas are also needed. The cost of draining and improving areas of Hebo silty clay loam, 0 to 3 percent slopes, is high because of the heavy subsoil. The cost is prohibitive in most places because, even after drainage, the soil is still low in fertility, very strongly acid, and suited to only a few crops.

This soil is droughty late in summer and early in fall. Irrigation by use of a sprinkler system is very beneficial to soil that has been properly drained. A low rate of water application and careful field checking are needed to prevent the accumulation of water above the very slowly permeable claypan. Irrigation should be repeated every 10 to 12 days, but the exact interval between irrigations and the rate of applying water should be determined by frequently checking soil moisture at depths of 12 to 18 inches in the field. Water for irrigation is available only from deep wells.

Pasture management consists of properly preparing seedbeds, rotating the grazing, harrowing, clipping, and controlling weeds. Grazing should not be allowed when the soil is saturated, as livestock compact the wet soil and injure the forage plants.

Most areas of this soil have been cleared of timber but are not drained. They support a growth of tussocks, or grasslike plants that grow in tufts, that have little or no forage value. Some areas are forested with Sitka spruce, western hemlock, or red alder.

#### CAPABILITY UNIT IVW-3

This capability unit consists of organic soil formed in very deep, partially decomposed beds of muck, fibrous peat, and raw vegetative material. It occurs in swales along tidelands and on the flood plains of streams. The nearly level surface is broken by low, broad hummocks. This soil has low natural fertility, is extremely acid, has a high water table, and is usually ponded. Permeability

is moderately rapid. The soil can hold less than 1 inch of water per foot of soil. The peat subsides rapidly on being aerated and fertilized. Much of this soil is difficult to rewet completely after having been thoroughly dried. The erosion hazard is none to slight. The soil in this capability unit is:

Brallier peat.

Climatically adapted specialty crops that can tolerate long periods of wetness and a restricted root zone grow well on this soil. After proper drainage has been installed, cranberries, blueberries, and shallow-rooted, water-tolerant grasses and legumes can be grown.

The standard crop rotation consists of soil-conserving crops three-fourths of the time and soil-depleting crops the rest of the time. The rotation may extend over many years. Most areas of this soil are unimproved swamps having tussocks, rushes, and a few scattered spruces. The soil is capable of more intensive use.

Fertilizer and soil amendments must be applied with care in order to mineralize the organic residue and provide available plant nutrients. Excessive use of fertilizer helps to decompose the peat. Lime is needed for successful growing of legumes. A good stand of high-quality grasses and legumes can be established and maintained by applying large amounts of lime, phosphate, nitrogen, and potash. Suitable legumes are big trefoil and alsike clover; a suitable grass is reed canarygrass.

The level of the water table must be carefully controlled to prevent the organic material from drying out. It is essential that controls allow the regulation of the water table height throughout the year. Dikes are needed to keep out surface water, and open ditches are needed for draining the surface. Subsurface drains must be placed at depths that control excessive subsidence. Tile should be laid on boards to prevent settling. Spacing of tile lines should be determined by characteristics of the soil. The joints of tile laid in sand must be blinded by use of tar paper. The use of wooden box drains may be advisable to maintain a grade where a firm bed is not available to support tile.

Pasture management consists of properly preparing seedbeds, rotating the grazing, harrowing, clipping, and controlling weeds.

#### CAPABILITY UNIT VIQ-1

The soils of this capability unit occur on rolling uplands. They are well drained, deep to moderately deep, and strongly acid. In addition, they have fine-textured subsoil and are underlain by weathered, highly fractured, soft shale. Runoff is medium, permeability is moderate, and the available water-holding capacity is medium to high. The hazard of erosion is moderate. When the soils are very wet, their structure collapses under pressure. Consequently, trafficability is a major problem during long wet periods. The soils in this capability unit are:

Astoria silt loam, 20 to 40 percent slopes.

Astoria silt loam, moderately deep, 20 to 40 percent slopes.

These soils are not suitable for cultivated crops, because they are too steep. In addition, they contain too many rock fragments and are poor in trafficability during long wet periods. Areas suited to pasture should be seeded to tall fescue with red clover or white clover.



Trees grow so well on these soils that they are generally best used for forest. Attempts to convert the soils to other uses may not be feasible or practical.

## CAPABILITY UNIT VIe-2

The soils of this capability unit occur on steep uplands that have sharp and irregular contours. They are deep to moderately deep, well-drained soils with moderately permeable subsoil. They are strongly to very strongly acid, have medium runoff, and are medium to moderately high in available water-holding capacity. Moderate amounts of basalt rock fragments are in the soil profile. Soil aggregates are very stable and provide good trafficability in long wet periods. The steep slopes and a moderate hazard of erosion are the main problems. The soils in this capability unit are:

Hembre silt loam, 20 to 40 percent slopes.

Hembre silt loam, moderately deep, 20 to 40 percent slopes.

These soils are not suitable for cultivated crops; they are too steep and have too many rock fragments in the profile. Trees grow well on these soils, and converting the soils to other uses is neither feasible nor practical.

## CAPABILITY UNIT VIe-3

The soils of this capability unit are adjacent to the coast. They occupy the windward side of smoothly rolling uplands underlain by sedimentary rock and the sharp, irregular uplands underlain by basalt bedrock. These soils are very high in organic matter, low in fertility, and strongly to very strongly acid. They are well drained, are deep to moderately deep, and have rapid runoff. They have a moderately permeable subsoil and are medium to high in water-holding capacity. The erosion hazard is moderate. The soils in this capability unit are:

Neskowin silty clay loam, 20 to 40 percent slopes.

Winema silt loam, 20 to 40 percent slopes.

Winema silt loam, moderately deep, 20 to 40 percent slopes.

These soils are not suitable for cultivation; they have steep slopes and too many rocks in the profile. Most areas are now used for pasture. Douglas-fir and Sitka spruce are scattered over these soils, but the cover consists mainly of brackenfern, salal, Scotch-broom, and grass. Yields of forage are low to fair; those of timber are moderate.

These soils are too steep to be safely cultivated for crops, but they can be prepared for the planting of trees or for seeding to pasture plants.

Pasture can be established and improved by heavy applications of lime, nitrogen, and phosphate. Potash should be applied when soil tests show a need for it. A suitable grass for better pasture is tall fescue; suitable legumes are subterranean clover and white clover. A good cover can be maintained on established pasture by clipping and harrowing and by scattering seed.

## CAPABILITY UNIT VIIs-1

The soil of capability unit VIIs-1 occupies narrow up-stream bottom lands, underlain by mixed alluvial materials. The surface has been made irregular by old stream channels and depressions. The soil is shallow, somewhat excessively drained, and very rapidly permeable. It is very low in available water-holding capacity

and is very low in fertility and organic matter. Runoff is slow. The erosion hazard from overwash is moderate. The soil in this capability unit is:

Gaudy loam, shallow, 0 to 7 percent slopes.

As this soil is shallow over gravel and subject to drought and overwash, it is not suited to cultivation. It is suitable for grasses and legumes used as pasture and for hemlock or redcedar woodland. Most of this soil in the Tillamook survey area is used for pasture.

Improved pasture can be established and maintained by applying lime, nitrogen, phosphate, and potash in amounts indicated by soil tests. Suitable grasses are tall fescue and orchardgrass; suitable legumes are red clover, subterranean clover, and white clover. If a good cover is to be maintained, pastures must be clipped and harrowed, and then seeded.

Irrigation is needed if the operator is to obtain satisfactory yields. Water should be applied about every 8 days or less during the dry part of the season. The rate and frequency of irrigation can be determined through checking soil moisture in the field. This soil requires lighter and more frequent applications of water than the finer textured soils.

## CAPABILITY UNIT VIIe-1

These soils are very steep and have large quantities of rock fragments in the profile. Runoff is rapid, and the hazard of erosion is severe. Soils in this capability unit are:

Astoria silt loam, 40 to 60 percent slopes.

Astoria silt loam, moderately deep, 40 to 60 percent slopes.

These soils are not suitable for cultivation. Many areas are deteriorating because management and the practice of conservation are not adequate.

## CAPABILITY UNIT VIIe-2

These soils are very steep and have large quantities of basalt fragments in the profile. Runoff is rapid, and the hazard of erosion is severe. Soils in this capability unit are:

Hembre silt loam, 40 to 60 percent slopes.

Hembre silt loam, moderately deep, 40 to 60 percent slopes.

These soils are not suitable for cultivation. Many areas are deteriorating because management and the practice of conservation are not adequate.

## CAPABILITY UNIT VIIe-3

The soil in this capability unit occupies very steep slopes on the windward side of sharp, irregular uplands near the coast. It is well drained, strongly acid, very high in organic matter, and moderately low in fertility. In addition, it is moderately deep, has a moderately slowly permeable subsoil, and is moderate in water-holding capacity. Runoff is rapid; erosion is severe. The soil in this capability unit is:

Neskowin silty clay loam, 40 to 60 percent slopes.

This soil is not suitable for cultivation, but it can be used for pasture. Improved pastures can be established by burning the shrubs and brackenfern and then broadcasting seed in the ashes. Suitable legumes are white clover and subterranean clover; a suitable grass is tall fescue.

Farm equipment should not be used on the soil. Livestock should not be allowed on the soil during long, wet periods.

## CAPABILITY UNIT VIIIc-4

The soil in this capability unit occupies stabilized dunes in isolated areas that occur along the Pacific Ocean and also extend inland for as much as 2 miles. These areas have typical dune topography, with moderate slopes on the windward side and strong to steep slopes on the leeward side. The soil is deep, very strongly acid, coarse textured, and well drained. Fertility and content of organic matter are low. Runoff is slow. The soil is very low in available water-holding capacity and has a very rapidly permeable subsoil. The hazard of wind erosion is severe. The soil in this capability unit is:

Netarts fine sandy loam, 7 to 30 percent slopes.

As this soil is droughty, coarse textured, and susceptible to severe erosion, it is not suitable for cultivation. Because of the hazard of wind erosion, this soil must be protected by a permanent cover of living vegetation. Most areas of this soil are in trees or are used for suburban development.

## CAPABILITY UNIT VIIIc-1

This unit consists of nonconforming strata of massive, coarse, gray, wind-drifted sand in dunes, hummocks, and ridges. It occurs along the Pacific Coast adjacent to the beach. It has no agricultural value. The miscellaneous land type in this capability unit is:

Active dune land.

Active dune land tends to increase in area, and if uncontrolled, will spread over and destroy vegetation in adjacent areas. In some places dunes are advancing on forests and are burying them; they also cover pastures, fill stream channels, cover roads, and interfere with local and tourist facilities. The reduced size of stream channels limits recreational use of the streams and interferes with the drainage of adjacent tidelands.

A considerable acreage of parks and recreational areas has been developed from sand dunes; much of the dune area is part of the ocean beach. Additional large areas of dunes, however, could be controlled and improved for recreational uses.

The movement of sand can be started by overgrazing, fire, jetties, construction of roads, wearing of trails, regrading of surface for building sites, and cultivation. In general, any destruction of the vegetation on sandy soil is likely to start the sand moving. When wind blows, the unprotected site becomes a blowout, which increases in size until its control requires a large amount of labor, material, and money.

The movement of sand can usually be stopped by planting beach grasses or dune grasses. If this is done, drift fences are not needed to check sand movement. The most severely damaged areas may initially require the use of sand fences before planting is done. (See figures 2 and 3.)

Beachgrass (*Ammophila* spp.) should be planted in the rainy season, between November 1 and May 15. Plant three culms or stems per hill—the hills spaced 16 to 18 inches apart in rows and between rows. Plant culms about 8 to 12 inches deep, and pack the sand firmly

around the stems. The planted area should be fertilized with 40 pounds of available nitrogen per acre early in spring every year until the plants are well established. After the sand has been stabilized, Scotch-broom should be planted on a 6 by 6 foot spacing. A year later, if Scotch-broom has a fair degree of survival, plant shore pine (*Pinus contorta*) over the area at a spacing of 8 by 8 feet. An occasional strip should be left unplanted to serve as an access road or future fire lane.

## CAPABILITY UNIT VIIIW-1

This unit consists of low coastal areas of marine peat and mud that are overwashed daily by tides. The miscellaneous land type in this capability unit is:

Tidal flats.

A considerable acreage of Tidal flats could be diked and drained by use of tide gates, open ditches, and tile. Costs would be high, but until these areas are drained, very little management can be applied or use obtained from these areas.

## CAPABILITY UNIT VIIIW-1

This capability unit consists of three miscellaneous land types—

Made land.  
Riverwash.  
Rock land.

Made land is in the Naval Air Station, south of Tillamook. Most areas of Made land are industrial sites, but a small part is used for field crops. The productivity of Made land can be improved if the soil is fertilized and properly managed.

Rock land areas can be used only by certain types of wildlife. They support a thin, scattered stand of trees that must be protected from fire. No other management is practical for Rock land.

Riverwash is located in active stream channels. It is not subject to deterioration and, in natural condition, can be used as a source of aggregate for mixing with cement. Willows growing on Riverwash should be protected. Additional areas of Riverwash should be planted to willows to reduce the velocity of floodwater and encourage siltation.

## Estimated Yields of Crops

The estimated average acre yields of dry forage obtained from mixtures of grasses and legumes grown under three levels of management are given in table 1. The yields shown are merely estimates but are reliable enough to be of value in planning soil management. The estimates are for long-term averages. Yields in any one year, and those from parts of fields with variations in soils, may differ from the yields given in the table. Past management is reflected for a few years, but it gradually ceases to be a factor if replaced by better management. Yields are also influenced by the use of new varieties of plants and by improved methods of farming.

The yields shown in column A (table 1) can be expected if the soils are properly drained, manured, and harrowed but are not limed. Pastures on these soils are not clipped, nor is the grazing on them rotated to other pastures to allow rest and regrowth before

TABLE 1.—*Estimated average acre yields of dry forage from mixtures of grasses and legumes grown under three levels of management*

[Levels of management are described in text]

Soil <sup>1</sup>	Dry grass-legume forage		
	A	B	C
	<i>Tons/acre</i>	<i>Tons/acre</i>	<i>Tons/acre</i>
Astoria silt loam, 3 to 12 percent slopes.....	1.5	2.5	5
Astoria silt loam, 12 to 20 percent slopes.....	1.5	2.5	5
Brallier peat.....	.5	2	5
Brenner silt loam.....	2.5	3.5	5
Chitwood silt loam, 0 to 7 percent slopes.....	2	3	5
Chitwood silt loam, 7 to 12 percent slopes.....	2	3	5
Coquille and Brenner silt loams.....	2.5	3	( <sup>2</sup> )
Gardiner fine sandy loam, 0 to 3 percent slopes.....	1.5	2.5	5
Gardiner fine sandy loam, overwashed, 3 to 7 percent slopes.....	1.5	2.5	5
Gauldy loam, 0 to 7 percent slopes.....	1.5	2.5	5
Ginger silt loam, 0 to 7 percent slopes.....	2	3	4
Hebo silty clay loam, 0 to 3 percent slopes.....	1.5	2.5	4
Hembre silt loam, 3 to 12 percent slopes.....	1.5	2.5	5
Hembre silt loam, 12 to 20 percent slopes.....	1.5	2.5	( <sup>2</sup> )
Knappa silt loam, 0 to 7 percent slopes.....	2	3	5
Knappa silt loam, 7 to 12 percent slopes.....	2	3	5
Knappa silt loam, moderately deep, 0 to 12 percent slopes.....	1	2	4
Meda gravelly loam, 3 to 12 percent slopes.....	1.5	2.5	5
Meda gravelly loam, 12 to 20 percent slopes.....	1.5	2.5	( <sup>2</sup> )
Nehalem silt loam, 0 to 3 percent slopes.....	2.5	4	5
Nehalem silt loam, overwashed, 3 to 7 percent slopes.....	2.5	4	5
Neskowin silty clay loam, 12 to 20 percent slopes.....	1.5	2.5	( <sup>2</sup> )
Nestucca silt loam.....	2.5	3.5	5
Quillayute silt loam, 0 to 7 percent slopes.....	2	3	4
Quillayute silt loam, moderately deep, 0 to 12 percent slopes.....	1	2	4
Winema silt loam, 3 to 12 percent slopes.....	1.5	2.5	4
Winema silt loam, 12 to 20 percent slopes.....	1.5	2.5	( <sup>2</sup> )
Winema silt loam, moderately deep, 12 to 20 percent slopes.....	1	2	( <sup>2</sup> )
Yaquina loamy fine sand, 0 to 3 percent slopes.....	.5	1.5	3

<sup>1</sup> Soils not suited to cultivation are omitted.

<sup>2</sup> Soil is not irrigated or is not suited to irrigation.

they are again grazed. The detailed description of this method, the least intensive level of management, is provided under the heading "Practices used to obtain two levels of yields."

The yields in column B can be expected if the soils are properly drained, manured, harrowed, limed, and fertilized. Pastures grown on them consist of improved

varieties of grasses and legumes, which are clipped and grazed in rotation with other pastures.

The yields in column C can be expected if supplemental irrigation by sprinklers is properly applied, in addition to the management needed to obtain the yields in column B. The detailed description of this method, the most intensive level of management, is provided under the heading "Practices used to obtain two levels of yields."

### *Practices used to obtain two levels of yields*

Farmers in the Tillamook survey area use two levels of management to obtain the yields shown in columns A and C of table 1. The yields shown in column A are obtained under the least intensive management; those in column C, under intensive management. Examples of the practices used to establish, maintain, harvest, and irrigate stands of grasses and legumes on Nehalem silt loam, 0 to 3 percent slopes, are given in the paragraphs that follow. Nehalem silt loam, 0 to 3 percent slopes, is in capability unit I-1. It is the highest in fertility and has the fewest management problems of any soil in the Tillamook survey area. Thus, all other soils in the survey area require more detailed management.

After grasses and legumes are established, they are used as pasture, or are harvested for hay or silage. Yields of dry forage obtained from Nehalem silt loam, 0 to 3 percent slopes, under intensive management average 5 tons per acre per year, or 15 animal-unit months of feed. Those obtained under the least intensive management average 2½ tons per acre per year, or 7½ animal-unit months of feed.

### ESTABLISHING GRASSES AND LEGUMES

Under intensive management, the establishment of grasses and legumes on Nehalem silt loam, 0 to 3 percent slopes, in a sod cover, consists of shallow disking to cut up sod, plowing with a moldboard plow, and disking twelve times to break up the sod. Two tons of lime and 400 pounds of 16-20-0 fertilizer are mixed with the soil by disking. The soil is then harrowed twelve times to smooth the surface and is rolled twice with a cultipacker to make a firm seedbed.

Seed is applied at the rate of 17 to 19 pounds per acre by use of a mechanical seeder, either from April 1 to June 1, or from August 15 to September 15. The seed mixture per acre generally consists of 8 pounds of tall fescue, 6 pounds of orchardgrass, and 3 pounds of white clover. Five pounds of subterranean clover may be used in place of 3 pounds of white clover.

Under the least intensive management, mixtures of grasses and legumes may be established in soil that contains the remains of trees. The soil is cleared of this debris and is given three deep diskings, five harrowings, and two rollings. Seeds of the same mixture are broadcast at the same rate per acre and at the same time of year as under intensive management.

### MAINTAINING GRASSES AND LEGUMES

Under intensive management, grasses and legumes are the permanent cover. Each year the stand gets 10 tons per acre of solid barnyard manure and some liquid manure, supplemented early in spring with 80 pounds per acre of available phosphoric acid. Every 5 years each acre gets 1 ton of lime. While pastures are

rested for regrowth, tufts of grass are clipped, droppings are spread, molehills are leveled, and noxious weeds are sprayed. Rodents are controlled any time of year.

Under the least intensive management, the stand of grasses and legumes has to be reestablished every 6 years because the desirable species are crowded out by other plants. Each acre gets 10 tons of solid manure and some liquid manure every 3 years. Between grazings, the less fertile areas are harrowed and noxious weeds are controlled. Rodents are controlled any time of year.

#### IRRIGATING GRASSES AND LEGUMES

Under intensive management, supplemental irrigation is applied in dry weather, generally at intervals of 12 to 14 days, or as determined by checking soil moisture in the field.

Under the least intensive management, supplemental irrigation is not applied.

#### HARVESTING GRASSES AND LEGUMES

Under intensive management, pastures are grazed in rotation with other pastures from April 1 to May 15 and again from July 1 to December 1. Hay is cut in the period of May 15 to July 1 when plants are in the early blooming stage and are tall enough for hay. Silage is made from any 6-weeks' growth of foliage when plants are in the early blooming stage.

Pastures are grazed until the foliage has been consumed to a stubble height of 2 inches and are then rested for about 3 weeks for regrowth, irrigation, and other needed management. Following the period of regrowth, livestock are turned back in, and the cycle of grazing and rest is repeated to the end of the grazing season—about December 1. Pastures are not grazed in winter or when wet; thus compacting of the soil and injuring forage plants by livestock are prevented.

Under the least intensive management, pastures are grazed all season and the grazing is not rotated with other pastures. Harvests of hay and silage, the restriction of grazing during winter, and the protection of soil and plants from trampling are the same as practiced under intensive management.

### Uses of Soils for Woodland<sup>3</sup>

Soils in the Tillamook survey area differ greatly in their suitability for trees. The species that grow on a soil are determined largely by a combination of soil, climate, and other natural conditions.

One of the most important factors that affect the productive capacity of a soil for trees is its ability to supply enough moisture for trees to grow and to develop an adequate root system. Other characteristics that affect soil productivity for trees are thickness of the surface layer, supply of plant nutrients, texture and consistence of the soil, depth to water table, and amount of air in the soil.

The potential of each soil for producing forest trees was determined by field measurements checked against site index tables. Site index values were projected from soils on which trees were measured to soils on which

<sup>3</sup>This section was written by WILLIAM J. SAUERWEIN, woodland specialist for western Oregon, Soil Conservation Service.



Figure 5.—Astoria soils. Loss of tree cover is the result of fire.

trees were not measured. Even though hardwoods occur, most soils are best suited to conifers (5).<sup>4</sup>

Hazards to the growing of trees are on all sites, even on the best ones. Uncontrolled fire and a dense understory of brush that interferes with the establishment of seedlings are major problems in forest management. Fire consumes trees and the ground cover and exposes the soil to accelerated erosion. Besides killing trees, fire opens the way to invasion of the burned area by insects and diseases (fig. 5).

Two kinds of fire do the greatest damage to small woodlands. These are spring fern fires and poorly attended land-clearing fires. Fern fires used to be set in the belief that they would improve the forage for grazing. Continued burning only encourages the growth of the fern.

<sup>4</sup>Italic numbers in parentheses refer to Literature Cited, page 74.



Before starting land-clearing fires, precautions should be taken to prevent their spreading. Cleared material should be piled for burning, fire trails opened, and all snags felled in the area before fires are set. In addition, burning should not be attempted when humidity is less than 35 percent or when wind is more than 8 miles per hour.

Slash resulting from logging is a fire hazard, the severity of which increases with the amount of slash on the ground. Slash ought to be piled during the logging of the trees. It can be burned only during the fire season because rain prevents burning it during the winter months. Local laws require that burning permits be obtained from the State fire warden before slash fires or clearing fires are set.

According to the 1949 Yearbook of Agriculture, high temperature, low humidity, and sudden wind set the stage for the Tillamook wildfire of August 1933. In 11 days this fire burned 267,000 acres of virgin forest in Oregon and destroyed a volume of timber equal to all the lumber cut in the United States in 1932.

### **Woodland suitability groups of soils**

To help landowners, the soils mapped in the Tillamook survey area are grouped according to their suitability for productive woodland. Each group is made up of soils similar in those characteristics and qualities that affect their management for woodland. This grouping is shown in table 2 and is further explained in the paragraphs that follow.

The site index ratings shown in table 2 are based on field measurements by employees of the Soil Conservation Service in the period from 1950 to 1961. The ratings of management hazards are based on the observations and experiences of employees of the Soil Conservation Service. The ratings in table 2 are considered to be tentative and are subject to revision as additional information becomes available.

The ratings of management problems shown in table 2 are defined as follows:

*Plant competition* refers to the interference of the brushy understory (mainly vine maple, alder, and other undesirable species) to the survival and growth of young forest trees (mainly Douglas-fir, hemlock, spruce, and shore pine). Plant competition is rated slight if the undesirable plants do not hinder the growth and establishment of seedlings of desirable species of forest trees. It is rated moderate when the undesirable species hinder but do not prevent the growth and establishment of desirable forest-tree seedlings. It is rated severe when the undesirable plants must be reduced to allow desirable forest-tree seedlings to survive and grow.

*Equipment limitation* is an evaluation of soil characteristics that is provided as a guide to owners and operators for restricting the use of logging equipment (trucks, tractors, and high-lead gear) during specified seasons of the year to prevent damage to soil and trees. Soil characteristics used, either separately or in combination with each other, to determine the degree of restriction are: Soil stability, gradient of slope, wetness, and stoniness. The restriction on type and use of equipment has been rated as slight, moderate, and severe.

Slight means that the type and use of equipment are restricted for less than 3 months per year; moderate means

that the type and use of equipment are restricted for 3 to 4 months per year; and severe means that the type and use of equipment are restricted for 4 to 6 months per year.

Where used in this section, the term *trafficability* refers to the ability of the structural aggregates of the soil to accept stress during prolonged periods of wetness. Excellent trafficability indicates forest equipment can operate throughout the year without destroying the soil structure. Good trafficability means equipment must be used carefully in long, wet periods. Fair trafficability means that equipment stresses will destroy soil structure when soil is very wet.

*Seedling mortality* is the expected degree of loss of forest-tree seedlings caused by soil and other environmental factors. Mortality is rated slight if there is little or no loss of seedlings—survival of 75 percent or more. Mortality is moderate if less than half the seedlings die—generally, a survival of 50 to 75 percent. Mortality is severe if more than half the seedlings die—survival of less than 50 percent.

*Windthrow* is associated with soil drainage, which is determined by permeability of the subsoil and topographic position. The rating for this problem refers to forest trees suited to each group of soils, as shown in table 2. The hazard of windthrow is rated slight on deep, well-drained soils that do not have a high water table. It is rated moderate on soils that have a moderate drainage restriction in the subsoil or that have a fluctuating water table. Windthrow is severe on soils that have poor internal drainage, have a high water table, or are in an area of high-velocity wind.

*Erosion hazard* is rated according to the degree of susceptibility of the soil to erosion because of slopes or physical properties. As a rule, the hazard is rated slight for soils having slopes of 0 to 20 percent; moderate for slopes of 20 to 40 percent; and severe for slopes of 40 percent or more. The ratings may differ, regardless of slope, for soils that are subject to blowing or to overwash. It is assumed that logging roads are built to acceptable standards of grade and drainage.

#### WOODLAND SUITABILITY GROUP 1

This group consists of well-drained to excessively drained soils on flood plains. The soils in this group are—

- Gardiner fine sandy loam, 0 to 3 percent slopes.
- Gauldy loam, 0 to 7 percent slopes.
- Nehalem silt loam, 0 to 3 percent slopes.

These soils generally have been cleared for cultivation. Some small, remote areas are still uncleared and are suited to permanent woodland production.

Plant competition on these soils is severe. Chemical sprays, clearing, burning, and other prescribed methods of preparing the seedbed and of treating woodland in the period after regeneration can be used to encourage the restocking of desirable species.

Equipment limitation is slight. The nearly level terrain and the sandy to silty soils provide rapid drainage and infiltration. Year-round operations are possible on these soils except in long periods of rain or when the soils are flooded.

TABLE 2.—*Site indexes and management problems by woodland suitability groups of soils*

(See text for additional discussion of management)

Suitability group and soils	Average site index of suitability group for— <sup>1</sup>			Species suited to soils in group	Management problems		
	Sitka spruce	Western hemlock	Douglas-fir		Plant competition	Equipment limitations	Seedling mortality
Group 1: Well-drained to excessively drained soils on flood plains: GaA, GmB, NaA.	160	<sup>2</sup> 160	<sup>2</sup> 160	Sitka spruce, western hemlock, Douglas-fir, black cottonwood, red alder.	Severe-----	Slight-----	Slight to moderate.
Group 2: Low stream deltas traversed by tidal sloughs: Co.	90	-----	-----	Sitka spruce-----	Severe-----	Severe-----	Severe-----
Group 3: Well-drained, moderately fine textured soils on terraces and fans: KaB, KaC, KmC, MeC, MeD.	185	185	185	Sitka spruce, western hemlock, Douglas-fir, western redcedar, red alder.	Severe-----	Slight to moderate.	Slight to moderate.
Group 4: Well-drained, moderately fine textured, dark-colored terrace soils: QaB, QmC.	155	<sup>2</sup> 155	-----	Sitka spruce, western hemlock.	Severe-----	Slight to moderate.	Slight-----
Group 5: Imperfectly drained to poorly drained, fine-textured soils on fans, low terraces, and flood plains: Br, ChB, ChC, GtB, HbA, Ns.	170	170	<sup>2</sup> 170	Sitka spruce, western hemlock, Douglas-fir, shore pine, western redcedar, red alder.	Severe-----	Moderate to severe.	Slight to moderate.
Group 6: Imperfectly drained, coarse-textured soils on fans and low terraces: YaA.	<sup>2</sup> 115	115	115	Sitka spruce, western hemlock, Douglas-fir, western redcedar, red alder.	Moderate---	Slight to moderate.	Slight-----
Group 7: Well-drained, fine to moderately fine textured, deep, gently sloping to moderately steep soils on foothills and low valley slopes over sedimentary rock: AsC, AsD, WeC, WeD, WmD.	190	190	<sup>2</sup> 190	Sitka spruce, western hemlock, Douglas-fir, western redcedar, red alder.	Severe-----	Moderate---	Slight-----
Group 8: Well-drained, fine to moderately fine textured, deep to moderately deep, steep soils on foothills and valley slopes over sedimentary rock: AsF, AtF, WeF, WmF.	190	190	190	Sitka spruce, western hemlock, Douglas-fir, western redcedar, red alder.	Moderate to severe.	Moderate---	Slight to moderate.



Group 9: Well-drained, fine to moderately fine textured, deep to moderately deep, very steep soils on hills over sedimentary rock: AsG, AtG.	200	195	185	Sitka spruce, western hemlock, Douglas-fir, western redcedar, red alder.	Moderate to severe.	Moderate.	Severe.
Group 10: Well-drained, moderately fine textured, deep, gently sloping to moderately steep soils on hills over igneous rock: HeC, HeD.	2 180	180	170	Douglas-fir, western hemlock, Sitka spruce, western redcedar, red alder.	Severe.	Slight.	Slight.
Group 11: Well-drained, moderately fine textured, deep to moderately deep, steep soils on hills over igneous rock: HeF, HmF.	-----	145	170	Douglas-fir, western hemlock, redcedar, red alder.	Severe.	Slight.	Slight.
Group 12: Well-drained, moderately fine textured, deep to moderately deep, very steep soils on hills over igneous rock: HeG, HmG.	-----	-----	150	Douglas-fir.	Moderate.	Slight.	Moderate.
Group 13: Well-drained, moderately fine textured, moderately deep, dark-colored, moderately steep soils on hills over igneous rock: NkD.	135	-----	-----	Sitka spruce.	Moderate.	Slight to moderate.	Moderate to severe.
Group 14: Well-drained, moderately fine textured, dark-colored, steep soils on hills over igneous rock: NkF.	145	-----	-----	Sitka spruce.	Moderate.	Moderate.	Moderate to severe.
Group 15: Well-drained, moderately fine textured, moderately deep, dark-colored, very steep soils on hills over igneous rock: NkG.	2 140	-----	-----	Sitka spruce.	Moderate.	Severe.	Moderate to severe.
Group 16: Well-drained, coarse-textured deep soils on hills: NtL.	150	-----	-----	Sitka spruce, shore pine.	Slight.	Slight.	Slight to moderate.
Group 17: Soils on flood plains subject to overwash and to ponding: Bp, GdB, GsB, NeB.	( <sup>1</sup> )	( <sup>3</sup> )	( <sup>3</sup> )	Various species of conifers or hardwoods.	( <sup>3</sup> )	( <sup>4</sup> )	( <sup>3</sup> )
Group 18: Miscellaneous land types: Ad, Ma, Re, Ro, Tf.	( <sup>1</sup> )	( <sup>4</sup> )	( <sup>4</sup> )	( <sup>4</sup> )	( <sup>4</sup> )	( <sup>4</sup> )	( <sup>4</sup> )

<sup>1</sup> An expression of the quality of soil for trees. The figure is the average height in feet of the dominant stand at the age of 100 years, rounded to nearest 5 feet. Absence of data in column indicates the species is not suited to soil.

<sup>2</sup> Estimated.

<sup>3</sup> Variable.

<sup>4</sup> Not suited to productive woodland.

Seedling mortality is slight to moderate because the soils are somewhat droughty in summer. Seedling mortality, however, is most generally caused by plant competition rather than by soil conditions.

The hazard of windthrow is slight. Roots can penetrate the soils easily and grow deeply. Winds of hurricane velocity cause windthrow, however.

The hazard of erosion is slight. In extreme high water, overflow may cause loss of soil material. Normally, very little loss occurs. Deposition may occur in some areas.

#### WOODLAND SUITABILITY GROUP 2

This group consists of poorly drained soils on low stream deltas that are traversed by tidal sloughs. The soils have a high water table. Unless protected by dikes, they are subject to tidal and fresh-water overflow. The soils in this group are—

Coquille and Brenner silt loams.

Most areas of these soils protected by dikes have been cleared for cultivation. Some will remain in their natural condition for a long time because clearing costs are high. Physical limitations and low productivity make these soils undesirable for woodland. It is doubtful if growing trees as a crop is economically feasible.

The main problems are poor regeneration, excessive windthrow, and the lack of accessibility. Natural stands of trees on these soils are never well stocked, because windthrow is continuous year after year. Winter storms and high tides may flood these soils. Consequently, seedlings are subject to drowning. In addition, salt water may kill seedlings along salt-water bays. These hazards greatly reduce the yield of wood, so long-term woodland management cannot be planned. If these soils are diked and drained, they may be cleared and made fairly productive for pasture.

#### WOODLAND SUITABILITY GROUP 3

This group consists of well-drained, moderately fine textured soils on fans and terraces. In some areas, the underlying gravel is near enough to the surface to affect productivity. The soils in this group are—

Knappa silt loam, 0 to 7 percent slopes.

Knappa silt loam, 7 to 12 percent slopes.

Knappa silt loam, moderately deep, 0 to 12 percent slopes.

Meda gravelly loam, 3 to 12 percent slopes.

Meda gravelly loam, 12 to 20 percent slopes.

Most areas of these soils have been cleared for cultivation. Small, inaccessible, and remote areas will probably remain in native vegetation.

Plant competition is severe on these soils. To insure adequate natural or artificial regeneration of desirable trees, areas of these soils should be treated by clearing, spraying, and burning the undesirable vegetation.

Equipment limitation is slight in areas that have a gravelly subsoil and is moderate in the other areas. Use of equipment must be restricted for 3 to 4 months in the fall, winter, and early spring because of heavy rainfall.

Seedling mortality varies from slight to moderate. On the gravelly areas mortality is moderate; on the deep soils, it is slight. Hazards other than soil characteristics are causes of seedling mortality.

The hazard of windthrow is generally slight, but winds of hurricane velocity cause an abnormal amount of

windthrow. Some areas adjacent to hills have a high water table and may also have a moderate windthrow problem.

Erosion hazards are slight on gentle slopes and are moderate on moderately steep slopes.

#### WOODLAND SUITABILITY GROUP 4

This group consists of well-drained, moderately fine textured, dark-colored soils on terraces. Most areas have been cleared, but a small acreage is still wooded. The soils in this group are—

Quillayute silt loam, 0 to 7 percent slopes.

Quillayute silt loam, moderately deep, 0 to 12 percent slopes.

Plant competition to desirable trees is severe. Salmonberry generally invades cutover areas and must be removed to insure adequate growth and survival of conifers.

The equipment limitation is slight on the highest areas. It is moderate in low areas next to bottom lands, mainly because drainage is blocked. Use of equipment is restricted for 3 to 4 months.

Seedling mortality is slight; good seedling survival of the desirable tree species is generally assured. Windthrow hazard is slight. Occasional winds of hurricane velocity are the main cause of windthrow.

The soils in this woodland suitability group are very stable and do not easily erode. Consequently, the hazard of erosion is slight.

#### WOODLAND SUITABILITY GROUP 5

This group consists of imperfectly drained to poorly drained, fine-textured soils on fans, low terraces, and flood plains. Most areas have been cleared for cultivation, but some are still in native vegetation because they are small or inaccessible. The soils in this group are—

Brenner silt loam.

Chitwood silt loam, 0 to 7 percent slopes.

Chitwood silt loam, 7 to 12 percent slopes.

Ginger silt loam, 0 to 7 percent slopes.

Hebo silty clay loam, 0 to 3 percent slopes.

Nestucca silt loam.

Plant competition is severe. A fluctuating high water table allows water-loving plants to grow well. Tree seedlings are generally smothered by the heavy growth of such plants. Spraying, clearing, or other measures are needed to insure the restocking of desirable plants.

The equipment limitation is moderate on the imperfectly drained soils and severe on poorly drained ones. Use of equipment is restricted for 3 to 6 months to prevent damage to the soils.

Seedling mortality is slight on the imperfectly drained soils and moderate on the poorly drained soils. Seedlings growing in depressions may be killed by the fluctuating high water table.

The hazard of windthrow is severe, especially during late winter storms when soils are saturated. The erosion hazard is slight, and only normal procedures are needed to prevent soil losses.

#### WOODLAND SUITABILITY GROUP 6

This group consists of an imperfectly drained, coarse-textured soil in basins and on low terraces. The only soil in the group is Yaquina loamy fine sand, 0 to 3 percent slopes. Most of this soil has not been cleared because drainage is a problem.



Plant competition is moderate. The evergreen understory slows restocking of desirable trees, but it does not prevent regeneration if there is an adequate source of tree seed.

Equipment limitation is slight to moderate because the sandy soil provides excellent trafficability. However, storms may restrict use of equipment for several months late in winter because they cause a rise in the water table.

Seedling mortality is slight. Survival is generally excellent because the water table is fairly high and roots can reach water. Stands tend to be overstocked.

The hazard of windthrow is severe because of a high water table during winter storms. Tree roots are in firm soil in the highest areas but not in drainageways. Individual, exposed trees generally blow over.

The erosion hazard is slight on gentle slopes and moderate on moderate slopes. Fires that consume the surface vegetation expose the soil and may cause wind erosion.

#### WOODLAND SUITABILITY GROUP 7

This group consists of well-drained, fine to moderately fine textured, deep soils on gently sloping to moderately steep foothills and low valley slopes over sedimentary rock. The soils in this group are—

- Astoria silt loam, 3 to 12 percent slopes.
- Astoria silt loam, 12 to 20 percent slopes.
- Winema silt loam, 3 to 12 percent slopes.
- Winema silt loam, 12 to 20 percent slopes.
- Winema silt loam, moderately deep, 12 to 20 percent slopes.

Many areas of these soils have been cleared and are used for pasture. Small acreages and remote areas are still in native vegetation.

Plant competition is severe. Abundant precipitation and the long, mild growing season favor a lush growth of shrubs and less desirable trees, which strongly compete with forest trees. Clearing, burning, spraying, and other methods of preparing seedbeds and treating land in the period after regeneration are needed to help restock woodland with desirable species.

The equipment limitation is moderate. The use of equipment is generally restricted for about 3 months a year, the actual time depending on moisture in the soils. If equipment is used when it should not be used, soil structure, soil stability, and tree roots can be seriously damaged.

Seedling mortality is slight. As a rule, mortality is the result of plant competition or animal damage. Neither drought nor soil texture is a problem.

The hazard of windthrow is moderate. Soils in depressions or in nearly level areas adjacent to steep slopes may be saturated in winter during periods of high wind velocity. Windthrow is severe in these areas.

The hazard of erosion is slight on the gentle and moderate slopes, and on moderately steep slopes. Normal practices are needed to control erosion.

#### WOODLAND SUITABILITY GROUP 8

This group consists of well-drained, fine to moderately fine textured, deep to moderately deep soils on steep hills over sedimentary rock. The soils are—

- Astoria silt loam, 20 to 40 percent slopes.
- Astoria silt loam, moderately deep, 20 to 40 percent slopes.
- Winema silt loam, 20 to 40 percent slopes.
- Winema silt loam, moderately deep, 20 to 40 percent slopes.

About 10 percent of the acreage of these soils is moderately deep, and 90 percent is deep. Nearly all areas are wooded. Competition to trees is moderate on upper slopes and convex surfaces, which are generally occupied by the moderately deep soils. It is severe on the lower slopes, where soils are generally deeper and where more moisture accumulates. Chemical sprays or hand clearing are generally needed when the competition is too severe for satisfactory regeneration and growth of trees.

The equipment limitation is moderate. The use of equipment generally has to be restricted for about 3 months per year to prevent damage to soil and tree roots. This period can be shortened by the use of cable logging systems. Tractor logging should not be practiced on these slopes, especially when the soils are wet.

Seedling mortality is moderate on south- and west-facing slopes occupied by soils of moderate depth. Otherwise, it is slight.

The hazard of windthrow is slight on upper and convex slopes and is moderate on concave and lower slopes. It varies according to the amount of moisture in the soils.

The hazard of erosion is moderate if logging is done by the conventional systems in which cables and roads are used.

#### WOODLAND SUITABILITY GROUP 9

This group consists of well-drained, fine to moderately fine textured, deep to moderately deep soils on very steep hills over sedimentary rock. The soils are—

- Astoria silt loam, 40 to 60 percent slopes.
- Astoria silt loam, moderately deep, 40 to 60 percent slopes.

About 10 percent of the acreage of these soils is moderately deep, and 90 percent is deep. Nearly all areas are wooded. Plant competition is moderate on upper slopes and convex surfaces, and it is severe on the lower, or concave surfaces, and in drainageways. Spraying, burning, or other prescribed treatment is needed to eliminate severe competition and favor the growth of trees.

The equipment limitation is moderate. Cable systems of logging should be used. The use of logging equipment may have to be discontinued or restricted for about 3 months during the wet season to prevent damage to the soils.

Seedling mortality is severe on all aspects because of damage caused by soil creep (fig. 6). Exposure causes mortality on south- and west-facing slopes. Mortality is most severe on upper convex slopes and is ordinarily moderately severe on lower slopes, though severity depends somewhat on the aspect.

The hazard of windthrow is moderate. It is least on the upper convex slopes and greatest on the lower concave slopes.

The erosion hazard is severe. Logging should be done carefully, and roads should be properly located, built, and drained to prevent serious erosion (fig. 7).

#### WOODLAND SUITABILITY GROUP 10

This group consists of well-drained, moderately fine textured, deep soils on gently sloping to moderately steep hills over igneous rocks. The soils are—

- Hembre silt loam, 3 to 12 percent slopes.
- Hembre silt loam, 12 to 20 percent slopes.



**Figure 6.**—The Astoria soils are unstable on steep slopes. The lack of a seed source has prevented natural reforestation on this slope for the past 28 years.

Many areas have been cleared for pasture. Odd corners and remote areas will probably remain uncleared. Plant competition to conifers is severe. Salmonberry generally invades logged areas, and it needs to be eradicated to encourage the survival and growth of conifers.

The equipment limitation is slight. Trafficability is good most of the time.

Seedling mortality is slight. Most of the mortality is caused by brush that overtops and smothers seedlings.

The hazard of windthrow is slight. These soils are permeable; trees are windfirm.

The hazard of erosion is slight. The soils are stable under the action of rain and running water.

#### WOODLAND SUITABILITY GROUP 11

This group consists of well-drained, moderately fine textured, deep to moderately deep soils on steep hills over igneous rock. The soils are—

Hembre silt loam, 20 to 40 percent slopes.

Hembre silt loam, moderately deep, 20 to 40 percent slopes.

The soils are mostly wooded. About 10 percent of their area is moderately deep, and 90 percent is deep.

Plant competition is usually severe, but it is moderate on the upper slopes of high hills and mountains. Salmonberry generally invades these soils after trees have been harvested. It has to be eradicated before good survival and growth of conifers can be obtained.

The equipment limitation is slight. Except in the wettest weather, the high-lead system can be used without damaging the soil.

Seedling mortality is slight because moisture is abundant during the growing season. The causes of mortality are generally not related to the soil.

The hazard of windthrow is slight. Roots can penetrate and trees are windfirm.

The hazard of erosion is moderate. Normal engineering practices will control erosion on roads and trails.





Figure 7.—The patch system is an improved method of harvesting woodlands. This system provides a network of access roads and an adequate source of seed for reforestation. It also helps in the control of fire erosion. (Courtesy Dept. of Forestry, State of Oregon.)

#### WOODLAND SUITABILITY GROUP 12

This group consists of well-drained, moderately fine textured, deep to moderately deep soils on very steep hills over igneous rock. The soils are—

Hembre silt loam, 40 to 60 percent slopes.

Hembre silt loam, moderately deep, 40 to 60 percent slopes.

These soils are nearly all wooded and should not be converted to other uses. About 10 percent of their acreage is moderately deep, and 90 percent is deep.

Plant competition is moderate. These soils are drier than those on gentler slopes, but the invasion of brush is not so severe. Regeneration of desirable trees occurs if a good seed source is available. Brush may have to be controlled in some places.

The equipment limitation is slight. Trafficability is excellent for high-lead logging systems.

Seedling mortality is moderate. Some loss is caused by drought, and some by soil creep and roll, which smother new seedlings. Large planting stock should be used.

The hazard of windthrow is slight. Roots can penetrate this soil, and the trees are generally windfirm except in winds of hurricane velocity.

The hazard of erosion is severe. The use of tractors on these soils should be restricted. Uphill high-lead yarding is desirable to prevent excessive disturbance of the soils. Roads and trails need extra maintenance to control erosion.

#### WOODLAND SUITABILITY GROUP 13

This group consists of a well-drained, moderately fine textured, moderately deep, dark-colored soil on moderately steep hills underlain by igneous rock. In this area only one soil is in this group—Neskowin silty clay loam, 12 to 20 percent slopes. This soil is mostly in grass, but scattered groves of spruce occur.

Plant competition is moderate from grasses or from shrubs. Natural regeneration of trees is generally obtained without treating the competing vegetation. However, the competition may have to be reduced or removed

to obtain the fullest growth and development of the desired trees.

The equipment limitation is slight to moderate. The use of equipment has to be restricted for less than 3 months in some years and for more than 3 months in others. If equipment is operated in wet weather, the soil and roots of trees are damaged.

Seedling mortality is moderate on north and east slopes and in areas protected from strong summer winds. It is severe on south and west slopes and in areas subject to strong summer winds.

The hazard of windthrow is slight. Roots easily penetrate these soils and anchor in the fractured, rocky substratum. Trees are windfirm.

The hazard of erosion is slight to moderate. Roads and trails used for tractor logging need careful maintenance for control of erosion.

#### WOODLAND SUITABILITY GROUP 14

This group consists of a well-drained, moderately fine textured, dark-colored soil on steep hills underlain by igneous rock. Only one soil is in this group—Neskowin silty clay loam, 20 to 40 percent slopes. This soil is mainly in grass, but groves of spruce occur in some places.

Plant competition is moderate from grasses or from shrubs. Natural regeneration of trees generally is obtained without treating the competing vegetation. However, the competition may have to be reduced to obtain the fullest growth of conifers.

The equipment limitation is moderate. The use of equipment generally has to be restricted more than 3 months each year to prevent damage to the soil and to tree roots.

Seedling mortality is severe on south- and west-facing slopes nearest the ocean, and it is moderate elsewhere.

The hazard of windthrow is slight. Trees anchor well in this soil. Extreme winds may cause some windthrow.

The hazard of erosion is moderate. Nearly all erosion can be prevented on properly drained roads if logging is done during the dry season. Poorly drained roads are severely eroded.

#### WOODLAND SUITABILITY GROUP 15

This group consists of well-drained, moderately fine textured, moderately deep, dark-colored soils on very steep hills that are underlain by igneous rock. Only one soil is in this group—Neskowin silty clay loam, 40 to 60 percent slopes. This soil is covered by grasses or by spruce trees.

Plant competition is moderate from grasses or from shrubs. In places the competition of thick growths of alder must be reduced before spruce can grow properly.

The equipment limitation is severe. Only uphill cable logging or other similar methods of logging should be used. The use of equipment should be restricted for 3 to 6 months to prevent damage to the soil.

Seedling mortality is severe on south and west slopes along the ocean; elsewhere it is moderate.

The hazard of windthrow is slight. Trees are windfirm if roots are not disturbed or cut by road-building or by logging equipment. Winds of hurricane velocity sometimes cause windthrow.

The hazard of erosion is severe on this soil. Logging should be done with care to prevent erosion.

#### WOODLAND SUITABILITY GROUP 16

This group consists of well-drained, deep, coarse-textured soils on hills. The only soil in this group is Netarts fine sandy loam, 7 to 30 percent slopes. This soil is mainly wooded; very little of it has been cleared for other purposes.

Plant competition is slight. Excellent germination and growth are generally obtained.

The equipment limitation is slight. Except during long storms, equipment can operate without damage to the soil.

Seedling mortality is moderate on south- and west-facing slopes and is slight on other slopes.

The hazard of windthrow is slight to moderate. It increases when trees become mature and very tall. Young trees on this soil are generally not damaged by windthrow.

The hazard of erosion is severe. This soil erodes easily by wind or water, and it should be used with care to prevent soil losses. Some type of permanent cover is desirable at all times for areas not in roads.

This soil is suitable for growing the evergreen floral shrubs—huckleberry, salal, and rhododendron. These plants can be harvested for bouquets and floral sprays.

#### WOODLAND SUITABILITY GROUP 17

This group consists of soils on flood plains subject to overwash or to ponding. The soils in this group are—

Brallier peat.

Gardiner fine sandy loam, overwashed, 3 to 7 percent slopes.

Gauldy loam, shallow, 0 to 7 percent slopes.

Nehalem silt loam, overwashed, 3 to 7 percent slopes.

These soils have very little commercial timber growing on them. They are highly variable in potential and suitability for commercial woodland. In addition, the hazards of management range from slight to severe.

#### WOODLAND SUITABILITY GROUP 18

This group consists of the following land types—

Active dune land.

Made land.

Riverwash.

Rock land.

Tidal flats.

These land types are not suited to trees and should not be considered for woodland use.

#### Woodland yield

The higher the quality of a woodland soil and the greater the favorability of other natural conditions, the faster is the diameter, height, and volume growth of single trees and of entire stands. Because of greater rapidity of growth, the early competition on good sites is keener than that on poor sites, and weaklings are eliminated more quickly. At a given age, therefore, woodland on a good site generally contains larger and taller, but probably fewer, trees than woodland on a poor site. Stand volume, accordingly is much greater on the good site.

Figure 8 shows the average annual per acre yield at 100 years of age for well-stocked, unmanaged stands of Sitka spruce, western hemlock, and Douglas-fir. Figures

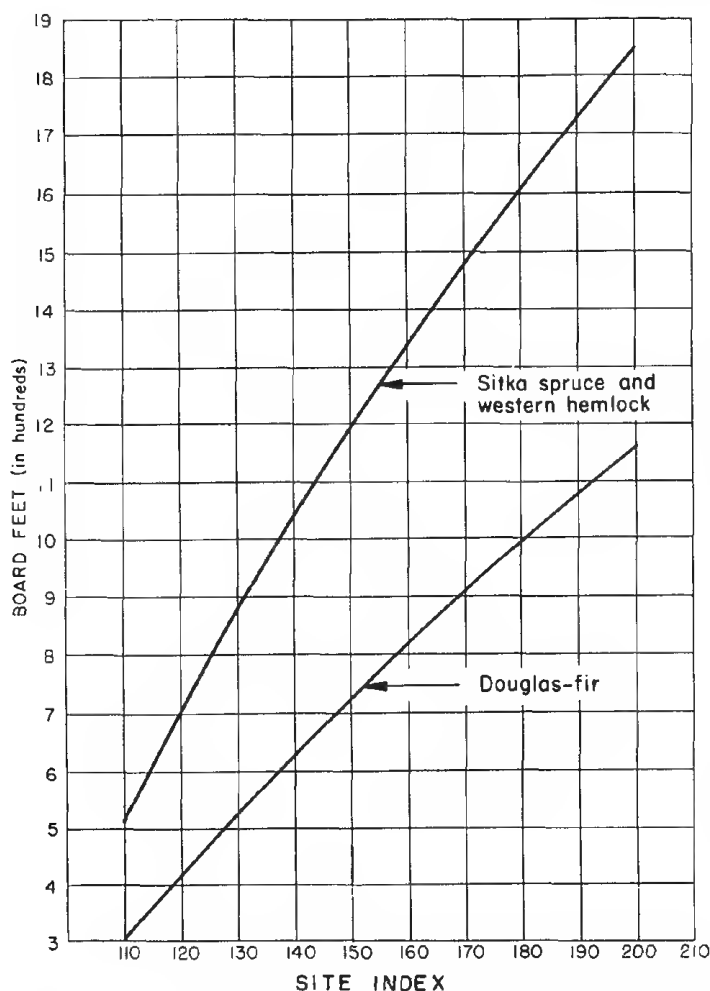


Figure 8.—Average annual per acre yield at 100 years of age for Sitka spruce, western hemlock, and Douglas-fir in well-stocked, unmanaged stands. Measurement is board feet, Scribner rule, in trees 12 inches and larger in diameter. (Adapted from the work of McArdle and Meyer (8, 9).)

from this chart may help the landowner to determine the potential productivity of his soil for wood crops and to guide him in selecting the proper use of his land.

## Engineering Properties of the Soils

This section is provided so that the soil survey information in this report can be more readily used for engineering purposes. The information can be used to—

1. Design dams, dikes, tide gates, and other soil and water conservation structures on farms and ranches.
2. Locate and design access roads and highways.
3. Estimate runoff, determine erosion hazards, and analyze other hydrologic characteristics that are important in the planning and preliminary design of watershed projects or terrain units.
4. Locate sources of sand, gravel, or fill material for construction purposes.

5. Determine the suitability of soils for industrial, business, residential, and recreational developments.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.

However, the mapping and descriptive report are somewhat generalized and should be used only in planning more detailed field investigations to determine the condition of the soil, in place, at the construction site.

In order to make the best use of the map and the descriptive report, the engineer should understand the classification system used by soil scientists. He should also have a knowledge of the physical properties of the soil material and of the condition of the soil when it is in place. Therefore, he should test the soil material and observe its behavior when used in engineering structures and foundations. Then the engineer can develop design criteria for the soil units delineated on the map.

### Soil test data

Samples from three extensive soil series in the Tillamook survey area were tested in accordance with standard AASHTO procedure (2) to help evaluate the soils for engineering purposes. The soil series selected for testing have characteristics that are similar to those of several other soil series. Consequently, the tested soils are a benchmark from which the engineering characteristics of soils not tested can be estimated. The profile of each tested soil was sampled to a depth of 5 feet at the modal site for the series. The test data are shown in table 3.

The engineering soil classifications in table 3 are based on data obtained by mechanical analyses and on tests made to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods. Percentages of clay obtained by these hydrometer method tests are suitable only for use in the AASHTO and Unified soil classification systems.

The values of the liquid limit and plasticity index indicate the effect of water on the consistence of soil material. These values help determine the load-bearing capacity of a soil. As the moisture content of a clayey soil increases from a very dry state, the material changes from a solid to a semisolid, or plastic, state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the material passes from a solid to a plastic state.

The liquid limit is the moisture content at which the material passes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which soil material is plastic.

The moisture-density determination reflects compaction characteristics of the tested soils. If a dry soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the density of the compacted material will increase until the "optimum moisture content" is reached. After that, the density decreases with increase in moisture content. The highest dry density obtained in the compaction test is termed "maximum density." Mois-



TABLE 3.—*Engineering test data*<sup>1</sup> for soil samples  
[Absence of data in a column indicates

Soil name and location	Parent material	Oregon State University report No.	Depth	Horizon	Moisture-density <sup>2</sup>	
					Maximum dry density	Optimum moisture
			<i>Inches</i>		<i>Lb. per cu. ft.</i>	<i>Percent</i>
Astoria silt loam: SW¼NE¼ sec. 23, T. 1 S., R. 8 W.-----	Eocene siltstone-----	240-3	0-19	A1	60	53
		240-2	19-50	B2	80	35
		240-1	50-77+	CDr	81	37
Coquille silt loam: NW¼NW¼ sec. 35, T. 3 N., R. 10 W.-----	Recent alluvium over tidal mud.	240-22	0-13	Apg	79	36
		240-23	19-40	C2g	77	34
		240-24	40-60+	D	93	26
Hebo silty clay loam: NE¼NE¼ sec. 14, T. 4 S., R. 10 W.-----	Recent alluvium (fans)---	240-35	0-4	Apg	76	37
		240-37	19-29	BG2	77	38
		240-36	29-38	BG3	88	30

<sup>1</sup> Tests were performed by Oregon State University under a cooperative agreement with the Oregon State Highway Department and the U.S. Department of Commerce, Bureau of Public Roads, in accordance with standard procedures of the American Association of State Highway Officials (2).

<sup>2</sup> Based on the Moisture-Density Relations of Soils Using 5.5-pound Rammer and 12-inch Drop, AASHTO Designation T 99-57, Method A (2).

<sup>3</sup> Mechanical Analyses according to the American Association of State Highway Officials Designation T 88-57. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure,

ture-density data are important in earthwork, for, as a rule, optimum stability is obtained if the soil is compacted to about the maximum density when it is at approximately the optimum moisture content.

Table 3 also gives the two engineering classifications for each soil sample. These classifications are based on the mechanical analysis, the liquid limit, and the plastic limit.

#### **Engineering classification and physical properties of the soils**

Many engineers classify a soil material by either the AASHTO (2, 11) or the Unified (15, 11) classification. Both classifications are based on the performance of soils under loads imposed by engineering uses. Gradation of materials as determined by the mechanical analysis and plasticity values have been found to correlate in general with performance characteristics under varied uses. The classification permits the engineer to make a rapid appraisal of the soil material by comparing it with other soils having the same classification.

Most highway engineers classify soil material in accordance with the AASHTO method. In this method soil material is classified in seven principal groups. The groups range from A-1, which is gravelly soil of high bearing capacity, to A-7, which consists of clay soil having a low strength when wet. In each group the relative engineering value of the soil material is indicated by a group index number. Group indexes range from 0 for the best material to 20 for the poorest. The group

index number is shown in parentheses following the soil group symbol; for example, A-4(8).

Some engineers prefer to use the Unified soil classification system. In this system soil material is divided into 15 classes that are designated by pairs of letters. Eight classes are for coarse-grained material, six for fine-grained, and one for highly organic material. Mechanical analyses are used to determine the GW, GP, SW, and SP classes of material; mechanical analyses, liquid limit, and plasticity index are used to determine GM, GC, SM, SC, and fine-grained materials. The Unified system is most useful for determining engineering suitability of soils for other than highway work.

The estimated engineering classifications and physical properties of soils by soil series and land types are shown in table 4. Estimates are generally given for the main horizons to a depth of as much as 5 feet.

In many types of construction, soil material is mixed and crushed, and the natural structural units are severely disturbed. Some uses of the soil, however, only partly disturb the profile. Uses in which soil is only slightly disturbed include development of urban areas and the logging of woodlands. For these uses, soil in place needs to have the capacity to carry a load.

Soils in the Tillamook survey area are strongly acid to extremely acid; concrete structures in these soils need special protection from the acidity. Tile used for drains must be made of clay or of a specially prepared grade of concrete.

taken from three soil profiles, Tillamook Area, Oregon

data are not available or not applicable]

Mechanical analysis <sup>3</sup>							Liquid limit	Plasticity index	Classification	
Percentage passing sieve—			Percentage smaller than—						AASHO <sup>4</sup>	Unified <sup>5</sup>
No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
100	93	74	63	41	17	9	<sup>6</sup> NP	<sup>6</sup> NP	A-4(8)-----	ML.
100	94	80	76	55	31	19	51	13	A-7-5(11)-----	MH.
100	86	59	57	47	28	16	58	11	A-7-5(7)-----	MH.
100	98	82	70	38	7	5	53	13	A-7 5(12)-----	MH.
100	98	73	59	32	9	5	50	11	A-7-5(10)-----	ML.
-----	100	62	-----	-----	-----	-----	39	8	A-4(5)-----	ML.
100	92	83	79	58	26	16	59	12	A-7-5(13)-----	MH.
100	94	87	84	76	62	52	74	21	A-7-5(16)-----	MH.
<sup>7</sup> 82	70	53	51	42	29	22	45	11	A-7-5(4)-----	ML.

the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

<sup>4</sup> Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing. The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation M 145-49 (2).

<sup>5</sup> Based on the Unified Soil Classification System, Technical Memorandum No. 3-357, Volume 1, Waterways Experiment Station, Corps of Engineers, March 1953 (15).

<sup>6</sup> NP=Nonplastic.

<sup>7</sup> Complete sieve analysis was as follows: 85 percent passed sieve No. 4; 90 percent passed 1-inch sieve; and 100 percent passed 3-inch sieve.

### Hydrologic groupings

Soils are placed in hydrologic groups according to their potential to yield runoff. Knowledge of runoff is needed to estimate volume and peak rate of runoff from specified areas for various lengths and intensities of storms. This information is used in the design of water-control structures.

The runoff potential of the soils in various hydrologic groups ranges from those that shed almost no precipitation (group A) to those that shed nearly all the precipitation (group D). Texture and depth of soil are good indicators of the absorptive capacity of a soil, but they may not determine the group in which a soil is placed. A moderately coarse textured soil may seal at the surface under the impact of rain and may, therefore, shed most of the water that falls on it. A soil of finer texture, however, may absorb rain more readily. Other factors may also be considered in grouping a soil. Soils in the Tillamook survey area have been placed in four hydrologic groups according to their potential to yield runoff.

**Group A.**—Coarse and moderately coarse textured soils and peat soils that transmit water through their profile and substratum at a high rate. These soils have the lowest runoff potential. Two land types, and soils of the following series, are in this group—

Active dune sand.  
Brallier series.  
Gauldy series.

Netarts series.  
Riverwash.  
Yaquina series.

The soils in this group have an area of about 8,989

acres, most of which is next to the ocean. The Brallier and Yaquina soils are frequently flooded.

**Group B.**—Medium- to fine-textured, moderately deep to very deep soils having a moderate rate of water transmission through the profile. Soils of the following series are in this group—

Astoria series.  
Coquille series.  
Gardiner series.  
Hembre series.  
Knappa series.

Meda series.  
Nehalem series.  
Neskowin series.  
Quillayute series.  
Winema series.

These soils have an area of about 114,508 acres. Those of the Coquille series are frequently flooded.

**Group C.**—Fine-textured, deep and very deep soils that have a slow rate of water transmission through the subsoil. One land type, and soils of the following series, are in this group—

Brenner series.  
Chitwood series.  
Ginger series.

Made land.  
Nestucca series.

These soils have an area of about 8,422 acres. All the soils, excluding Made land, are frequently flooded.

**Group D.**—Fine-textured, deep soils, and impervious material exposed or covered by a thin mantle of soil. These soils have the highest runoff potential. In this group are—

Rock land.  
Tidal flats.

Hebo series.

These soils have an area of about 3,909 acres.

TABLE 4.—*Brief descriptions of soils and their estimated*

[Absence of data in column indicates

Soils, map symbols, and descriptions <sup>1</sup>	Restriction to the movement of water and its depth from surface <sup>2</sup>	Dominant slope range	Trafficability in long, wet periods <sup>3</sup>
Active dune land (Ad): Moving, wind-segregated sand	None	Percent	Good
Astoria <sup>7</sup> (AsC, AsD, AsF, AsG, AtF, AtG): Deep, well-drained upland soil formed in sedimentary residuum; substratum moderately restricts movement of water; very strongly acid.	Soft, fractured siltstone at 50 to 77 inches.	20-40	Poor
Brallier (Ep): Very deep, poorly drained organic soil with a strong restriction to movement of water in subsoil; surface layer is very strongly to extremely acid.	High water table at 0 to 6 inches; residual peat in discontinuous layers as much as 4 inches thick at a depth of 6 inches or more.	0-3	None
Brenner (Br): Deep, imperfectly drained soil on flood plains consisting of mixed alluvium; has moderately strong restriction to movement of water; flooded in high water; strongly acid.	High water table at 7 to 13 inches; silty clay substratum at 21 to 24 inches.	0-3	Very poor
Chitwood (ChB, ChC): Deep, imperfectly drained soils formed on terraces in mixed old alluvium derived from shale; moderately strong restriction to movement of water in subsoil; very strongly acid.	Silty clay subsoil at 23 to 27 inches	0-7	Very poor
Coquille <sup>7</sup> (Co): Deep, poorly drained soil on tideland and flat stream deltas subject to inundation; formed in mixed recent alluvium; moderately strong restriction to flow of water in substratum; very strongly to extremely acid.	High water table at 0 to 6 inches; silty or clayey tidal mud at 24 to 40 inches.	0-3	None
Gardiner (GaA, GdB): Deep, well-drained sandy loam formed in mixed alluvium on flood plains; no restriction to movement of water; flooded at times; strongly acid.	None	0-3	Good
Gauldy (GmB, GsB): Deep, somewhat excessively drained soil formed in mixed recent alluvium on flood plains of streams with gravelly beds; no obstructions to movement of water; strongly acid.	None	0-7	Good
Ginger (GtB): Deep, imperfectly drained soil formed in mixed old alluvium on terraces; moderately strong restriction to movement of water in subsoil; surface layer high in organic matter and very strongly acid.	Silty clay subsoil at 20 to 26 inches; cemented gravel in substratum at 52 to 60 inches.	0-3	None
Hebo <sup>7</sup> (HbA): Deep, poorly drained soil formed in sedimentary and mixed alluvium on fans and terraces; strong restriction to movement of water in subsoil; surface layer moderately high in organic matter and very strongly acid.	Clay subsoil at 10 to 14 inches	0-3	None
Hembre (HeC, HeD, HeF, HeG, HmF, HmG): Deep to moderately deep, well-drained upland soil on hard basalt bedrock; nearly complete restriction to vertical movement of water in substratum; very strongly acid.	Basalt bedrock at 30 to 48 inches	40+	Fair

See footnotes at end of table.



*engineering classifications and physical properties*

data are not applicable or not available]

Horizon depth from surface	Classification		Liquid limit	Plasticity index	Suitability as source of—		
	AASHO	Unified			Topsoil <sup>4</sup>	Fill <sup>5</sup>	Sand or gravel
<i>Inches</i> 0-60+	A-2 or A-3	SM or SP	( <sup>6</sup> )	( <sup>6</sup> )	Not suitable	Poor; good if stabilized.	Poor.
0-19	A-4	ML	( <sup>6</sup> )	( <sup>6</sup> )	Good	Poor; organic surface soil.	Not suitable.
19-50	A-7-5	MH	51.0	13.0	Fair	Fair	Not suitable.
50-77+	A-7-5	MH	58.0	11.0	Not suitable	Fair	Not suitable.
0-24		Pt.			Not suitable	Not suitable	Not suitable.
24-48		Pt.			Not suitable	Not suitable	Not suitable.
48-60		Pt.			Not suitable	Not suitable	Not suitable.
0-13	A-6 or A-7	ML or MH	50.0	12.0	Good	Poor; wet plastic clay.	Not suitable.
13-52	A-6 or A-7	MH or CH	65.0	15.0	Poor	Poor; wet plastic clay.	Not suitable.
0-11	A-6 or A-7	ML or MH	50.0	12.0	Good	Poor; wet plastic clay.	Not suitable.
11-45	A-6 or A-7	MH or CH	60.0	15.0	Poor	Poor; wet plastic clay.	Not suitable.
0-13	A-7-5	MH	53.0	13.0	Not suitable	Not suitable; layered peat.	Not suitable.
19-40	A-7-5	ML	50.0	11.0	Not suitable	Not suitable; layered peat.	Not suitable.
40-60	A-4	ML	39.0	8.0	Not suitable	Not suitable; layered peat.	Not suitable.
0-3	A-2 or A-4	ML or SM	( <sup>6</sup> )	( <sup>6</sup> )	Fair	Good	Fair for sand; not suitable for gravel.
3-45+	A-2 or A-4	SM	( <sup>6</sup> )	( <sup>6</sup> )	Poor	Fair; good if stabilized.	Good for sand; not suitable for gravel.
0-26	A-2 or A-4	ML or SM	38.0	6.0	Good	Good	Not suitable.
26-55	A-2 or A-4	ML, SM or GM	( <sup>6</sup> )	( <sup>6</sup> )	Poor	Good	Fair for gravel; not suitable for sand.
55-60+					Not suitable	Good	Good for gravel; not suitable for sand.
0-17	A-6 or A-7	ML or CL	50.0	11.0	Good	Not suitable; organic matter in surface layer.	Not suitable.
17-52	A-6 or A-7	MH or CH	60.0	13.0	Poor	Poor; wet plastic clay.	Not suitable.
52+	A-4 or A-6	GM or GP	33.0	5.0	Not suitable	Good	Good for gravel; not suitable for sand.
0-10	A-7-5	MH	59.0	12.0	Fair	Poor; organic matter in surface layer.	Not suitable.
10-35	A-7-5	CH	74.0	21.0	Not suitable	Not suitable; wet plastic clay.	Not suitable.
35-42+	A-7-5	CH or MH	45.0	11.0	Not suitable	Not suitable; wet plastic clay.	Not suitable.
0-11	A-6 or A-7	ML or CL	50.0	10.0	Good	Fair	Not suitable.
11-38	A-6 or A-7	MH or CL	45.0	8.0	Fair	Fair	Not suitable.
38+	A-2 or A-4	GP or GM	35.0	6.0			Not suitable.

TABLE 4.—*Brief descriptions of soils and their estimated*

Soils, map symbols, and descriptions <sup>1</sup>	Restriction to the movement of water and its depth from surface <sup>2</sup>	Dominant slope range	Trafficability in long, wet periods <sup>3</sup>
<b>Knappa (KaB, KaC, KmC):</b> Deep to moderately deep, well-drained soils formed in old alluvium on terraces; moderate restriction to movement of water in subsoil; very strongly acid.	Silty clay loam subsoil at 14 to 16 inches.	Percent 0-7	Fair to good..
<b>Made land (Ma):</b> Very deep, heterogeneous mass of soil material without consistent profile characteristics.	None.....		
<b>Meda (MeC, MeD):</b> Deep, gravelly, well-drained soils formed in mixed alluvium on fans; no restriction to movement of water; strongly acid.	None.....	3-7	Good.....
<b>Nehalem (NaA, NeB):</b> Deep, well-drained soils formed in mixed recent alluvium on flood plains; moderately high in organic matter; no restriction to movement of water; soil occasionally flooded.	None.....	0-3	Poor.....
<b>Neskowin (NkD, NkF, NkG):</b> Moderately deep, well-drained upland soils underlain by hard basalt; surface layer high in organic matter; nearly complete restriction to the movement of water in substratum; strongly acid.	Basalt bedrock at 20 to 36 inches.....	20-40	Fair.....
<b>Nestucca (Ns):</b> Deep, moderately well drained soils formed in mixed recent alluvium on flood plains; moderately strong restriction to movement of water in substratum; covered by water in floods; strongly acid.	Water table at 10 to 20 inches; silty clay substratum at 36 to 48 inches.	0-3	Very poor....
<b>Netarts (NtE):</b> Deep, well-drained sandy soil formed in wind-worked dunes on marine terraces adjacent to the ocean; no restriction to movement of water; very strongly acid.	None.....	7-30	Good.....
<b>Quillayute (QaB, QmC):</b> Deep to moderately deep, well-drained soils formed in old mixed alluvium on terraces; surface layer high in organic matter; no restriction to movement of water; very strongly acid.	None.....	0-7	Fair to good..
<b>Riverwash (Re):</b> Heterogeneous mass of boulders, cobbles, stones, gravel, and sandy alluvium in and along stream channels.	None.....		Fair to good..
<b>Rock land (Ro):</b> Hard basalt bedrock exposed on 40 to 70 percent of area or covered by very shallow soil; no agricultural value.	Basalt bedrock less than 10 inches from surface.	30-40	.....
<b>Tidal flats (Tf):</b> Strata of silt, silty clay, clay, and sand on level to concave areas; regularly covered by tides.	.....		
<b>Winema (WeC, WeD, WeF, WmD, WmF):</b> Deep, well-drained soils formed in sedimentary residuum on uplands; surface layer high in organic matter; moderate restriction to movement of water in subsoil; very strongly acid.	Siltstone bedrock at 60 to 80 inches....	20-40	Poor.....

See footnotes at end of table.

## engineering classifications and physical properties—Continued

Horizon depth from surface	Classification		Liquid limit	Plasticity index	Suitability as source of—		
	AASHTO	Unified			Topsoil <sup>4</sup>	Fill <sup>5</sup>	Sand or gravel
<i>Inches</i> 0-14 14-60+	A-6 or A-7 A-6 or A-7	ML or CL ML or CL	50.0 45.0	10.0 8.0	Good Fair	Fair Fair	Not suitable. Not suitable.
					Not suitable	Not suitable	Not suitable.
0-9	A-4	ML or GM	35.0	5.0	Good	Good	Poor for gravel; not suitable for sand.
9-24	A-4 or A-6	ML or GM-GC	( <sup>6</sup> )	( <sup>6</sup> )	Poor	Good	Fair for gravel; not suitable for sand.
24-36+	A-2 or A-4	SM or GM	( <sup>6</sup> )	( <sup>6</sup> )	Poor	Good	Fair for gravel; not suitable for sand.
0-8	A-6 or A-7	ML or CL	50.0	12.0	Good	Poor; organic matter in surface layer.	Not suitable.
8-60+	A-6 or A-7	MH or CL	48.0	11.0	Fair	Fair	Not suitable.
0-12	A-6	ML or MH	50.0	10.0	Good	Not suitable; organic matter in surface layer.	Not suitable.
12-27 27+	A-6 or A-7 A-2 or A-4	ML or CL GM	45.0 35.0	8.0 6.0	Fair	Fair	Not suitable. Not suitable.
0-14	A-6 or A-7	ML or MH	50.0	12.0	Good	Poor; organic matter in surface layer.	Not suitable.
14-60+	A-6 or A-7	MH or CH	60.0	14.0	Poor	Poor; wet plastic clay.	Not suitable.
0-13	A-2 or A-4	SM	( <sup>6</sup> )	( <sup>6</sup> )	Fair	Fair	Poor for sand; not suitable for gravel.
13-52	A-2 or A-3	SP or SM	( <sup>6</sup> )	( <sup>6</sup> )	Not suitable	Fair; good if stabilized.	Fair for sand; not suitable for gravel.
52-65+	A-2 or A-3	SW	( <sup>6</sup> )	( <sup>6</sup> )	Not suitable	Fair; good if stabilized.	Good for sand; not suitable for gravel.
0-21	A-7	ML or CL	50.0	10.0	Good	Not suitable; organic matter in surface layer.	Not suitable.
21-60+	A-4 or A-6	ML, CL or GM	48.0	8.0	Fair	Good	Not suitable.
	A-2	SM or GM	( <sup>6</sup> )	( <sup>6</sup> )	Not suitable	Good	Good for sand and gravel.
							Not suitable.
							Not suitable.
0-21	A-7 or A-1	ML	50.0	12.0	Good	Not suitable; organic material in surface layer.	Not suitable.
21-42 42-60+	A-6 or A-7 A-6 or A-7	MH or CH MH or CH	55.0 58.0	14.0 15.0	Poor Poor	Fair Fair	Not suitable. Not suitable.



TABLE 4.—*Brief descriptions of soils and their estimated*

Soils, map symbols, and descriptions <sup>1</sup>	Restriction to the movement of water and its depth from surface <sup>2</sup>	Dominant slope range	Trafficability in long, wet periods <sup>3</sup>
Yaquina (YaA): Deep, imperfectly drained sandy soils formed in dune material in concave and level areas between old dunes; no restriction to movement of water; very strongly acid.	None-----	Percent 0-3	Good-----

<sup>1</sup> Terms referring to restrictions in the flow of water in the soil have the following meaning: Moderate restriction allows a flow of about 0.80 to 2.50 inches of water per hour; moderately strong restriction allows a flow of about 0.20 to 0.80 inch of water per hour; and strong restriction allows a flow of less than 0.20 inch per hour.

<sup>2</sup> Restriction refers to a layer that slows or prevents movement of water through the soil. The restriction can be caused by a significant difference in permeability or by a water table. Textural terms are those used by the USDA system (14).

<sup>3</sup> Trafficability refers to the ability of a soil to accept loads.

## Descriptions of the Soils

In this report, the soils are described in approximate alphabetical order. Their acreage and proportionate extent are shown in table 5, and their location in the survey area can be seen on the detailed map at the back of the report. Figure 9 shows a generalized cross section of the Tillamook coastal plain and the occurrence of soils according to topographic position. Figure 10 shows where the cross section is located on the coastal plain.

The soil series are described first, and after each series, the soils of that series that were mapped in the survey area. An important part of each soil description is the soil profile, a record of what the soil scientist learned when he dug into the ground. Since all the soils in one series have essentially the same profile, except for possible differences in texture of the surface layer, it is not necessary to describe the profile of every soil. The profile is therefore described for the first soil of each major type. The reader can assume that all the other soils of one type have essentially the same kind of profile. For example, a detailed profile is described for Astoria silt loam, 20 to 40 percent slopes, and the reader is to conclude that all the Astoria silt loams mapped have essentially this kind of profile. The differences, if any, are indicated in the soil name or are mentioned in describing the particular soil.

The profile description is in smaller type than the rest of the description of the soil. Those who want to have only a working knowledge of the soil and its management need read only the part set in larger type.

The capability unit and the woodland suitability group into which each soil in the survey area has been placed are stated at the end of each soil description.

The technical descriptions of soil profiles are given in the section "Genesis, Classification, and Morphology of the Soils" to which all readers are referred who desire more detailed descriptions and laboratory analyses of soil layers. In this technical section, soil color is described by use of Munsell notations.

Many technical terms used by scientists to describe soils are defined in the Glossary in the back of this report.

## Active Dune Land (Ad)

This land type consists of wind-drifted sand in the form of dunes, ridges, or hummocks. The material is not stabilized and has no vegetation on it. Active dune land occupies considerable acreage along the coast adjacent to the beach. It consists of grayish-brown, incoherent, porous sand and fine sand, dominantly feldspathic in composition.

Dunes are generally 5 to 40 feet high; they have a maximum elevation of about 80 feet. The relief is a monotonous succession of irregularly distributed dunes and ridges, which rise above the intervening wind-formed valleys, pockets, and swales. Dunes are either bare of vegetation, or the growth is not dense enough to protect the sand and to prevent it from blowing. Consequently, the dunes are constantly shifting under the influence of strong ocean winds and, in some places, are advancing slowly over the forest.

Active dune land has no agricultural value but is used for recreational areas. Considerable acreage of shifting dunes has been stabilized through the efforts of the Soil Conservation Service, State Park Commission, beach communities, and individuals. Stabilization of shifting sand first requires the planting of beachgrass to control the movement of sand, followed by plantings of Scotch-broom and shore pine. (Capability unit VIIIe-1; woodland suitability group 18.)

## Astoria Series

The Astoria series consists of well-drained, fine-textured soils derived from weathered soft shale. The Astoria soils are among the main upland soils in the Tillamook survey area. They occupy very steep, rough mountain slopes in the coast range and gentle to steep, valley foothills. They are associated with the Hembre, Winema, and Neskowin soils. Astoria soils on the steep slopes are in forests of Douglas-fir, hemlock, cedar, and red alder. Those near the coast are in Sitka spruce.

The surface soil is very dark grayish brown, friable, and granular. The subsoil is dark yellowish brown, firm, and blocky. The profile is underlain at varying

*engineering classifications and physical properties—Continued*

Horizon depth from surface	Classification		Liquid limit	Plasticity index	Suitability as source of—		
	AASHO	Unified			Topsoil <sup>4</sup>	Fill <sup>5</sup>	Sand or gravel
Inches							
0-3	A-2 or A-4	SM	35.0	5.0	Fair	Not suitable	Not suitable.
3-30	A-2 or A-3	SM or SP	( <sup>6</sup> )	( <sup>6</sup> )	Poor	Fair; good if stabilized.	Fair for sand; not suitable for gravel.
30-42+	A-2 or A-3	SP or SM	( <sup>6</sup> )	( <sup>6</sup> )	Poor	Poor; good if stabilized.	Good for sand; not suitable for gravel.

<sup>4</sup> The suitability of a soil material for topsoil refers to its use in topdressing compacted fill, roadbanks, slopes, ditches, lawns, and gardens to promote the growth of vegetation.

<sup>5</sup> The suitability of soil material for fill refers to its use in embankments and water-control structures.

<sup>6</sup> Nonplastic.

<sup>7</sup> Test data from samples of this soil are given in table 3.

depths by soft, gray and yellowish-brown shale. In most areas fractured fragments of shale are scattered throughout the profile. The soils in concave positions are very deeply weathered; on hills and upper slopes, they are weathered less deeply and generally contain a great many fragments of shale.

A large acreage of gently to strongly sloping Astoria soils of the foothills has been cleared and is used for pasture and forage crops.

**Astoria silt loam, 20 to 40 percent slopes (AsF).**—This soil occupies the steep lower slopes of the coast range.

Representative profile observed in a logged area now in a scattered new growth of Douglas-fir and red alder, and a ground cover of brackenfern:

Surface layer—

0 to 19 inches, very dark grayish-brown, friable (dark brown and soft, dry) silt loam; granular structure; small, shotlike concretions of iron common.

Subsoil—

19 to 28 inches, dark yellowish-brown, friable, light silty clay; subangular blocky structure; sticky and plastic when wet.

28 to 45 inches, dark yellowish-brown, firm, light silty clay; blocky structure; sticky and plastic when wet.

45 to 50 inches, yellowish-brown, firm, heavy silty clay loam; blocky structure; sticky and plastic when wet; numerous fragments of fractured shale.

Substratum—

50 to 60 inches +, highly weathered, soft shale; very strongly acid.

The main variation is in the amount of weathered shale fragments in the subsoil. In some areas the subsoil contains up to 30 percent shale fragments, and in other areas the subsoil contains no shale. The foot slope locations contain much shale rubble that sloughed from the slopes above.

Intermittent pockets of the Chitwood soils in sloping concave areas are included with this soil. In transitional zones along terraces and fans, small areas of Knappa, Hebo, or Meda soils are included. In transitional areas near basalt bedrock, small areas of Hembre soils may be included.

Natural drainage is good, subsoil permeability is moderate, and runoff is medium. The available water-holding capacity is high, and the penetration of roots is deep.

The hazard of erosion is moderate. The soil is high in organic matter, medium in fertility, and very strongly acid.

This soil is mainly in timber, except for a few isolated clearings that are used for pasture. The most valuable forest trees are Douglas-fir and hemlock. (Capability unit VIe-1; woodland suitability group 8.)

**Astoria silt loam, 40 to 60 percent slopes (AsG).**—This soil occupies the rough mountain slopes in the coast range. It is similar to Astoria silt loam, 20 to 40 percent slopes, except that it has stronger slopes, and the average depth to highly weathered, soft shale is 36 to 40 inches. Included are many small areas of Astoria silt loam, moderately deep, 40 to 60 percent slopes, that are too small to be mapped separately. Runoff is rapid, and the hazard of erosion is severe (fig. 11).

This soil is mainly in forests, in which Douglas-fir and hemlock are the most valuable species. A few acres have been cleared and are used for pasture and forage crops. (Capability unit VIIe-1; woodland suitability group 9.)

**Astoria silt loam, 12 to 20 percent slopes (AsD).**—This soil occupies the moderately steep lower slopes of valleys and foothills. Except for slopes, it is similar to Astoria silt loam, 20 to 40 percent slopes. The erosion hazard is moderate when the soil is cultivated, and it is slight in woodlands during logging operations.

The soil is mainly in forests, in which Douglas-fir and hemlock are the most valuable trees. A few acres have been cleared and are used for pasture and forage crops. (Capability unit IVe-1; woodland suitability group 7.)

**Astoria silt loam, 3 to 12 percent slopes (AsC).**—This soil occupies the gentle to rolling slopes in the lower foothills in association with the Knappa and Meda soils. Except for slopes, the soil is similar to Astoria silt loam, 20 to 40 percent slopes. The hazard of erosion is slight. A few small areas of Astoria silt loam, 3 to 12 percent slopes, are on slopes of less than 3 percent.

Approximately half of this soil is used for pasture and forage crops. The other half is in forests, in which Douglas-fir and hemlock are the most valuable species. (Capability unit IIIe-1; woodland suitability group 7.)

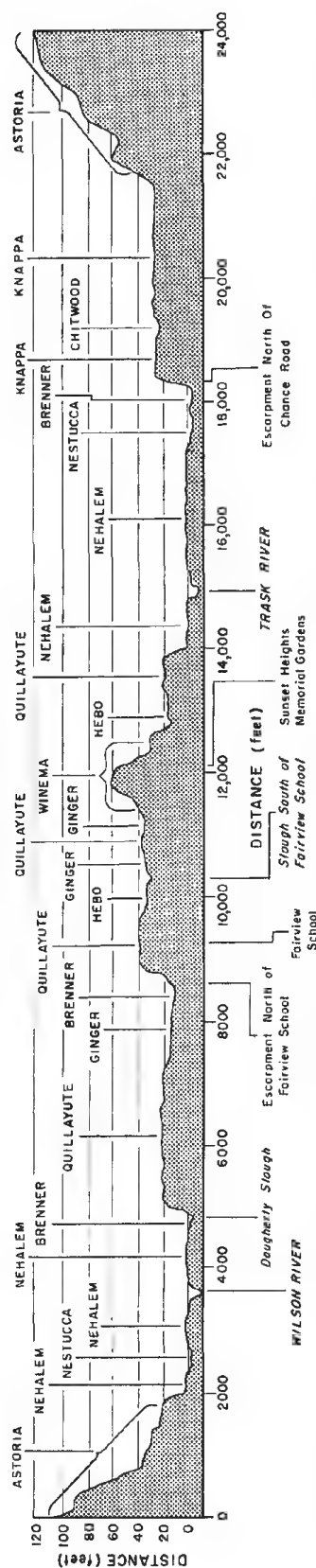


Figure 9.—Generalized cross section of the Tillamook coastal plain showing the occurrence of soils in relation to topography. The cross section runs southeast from a point near the Wilson River to mountains beyond the Trask River. (See figure 10.)

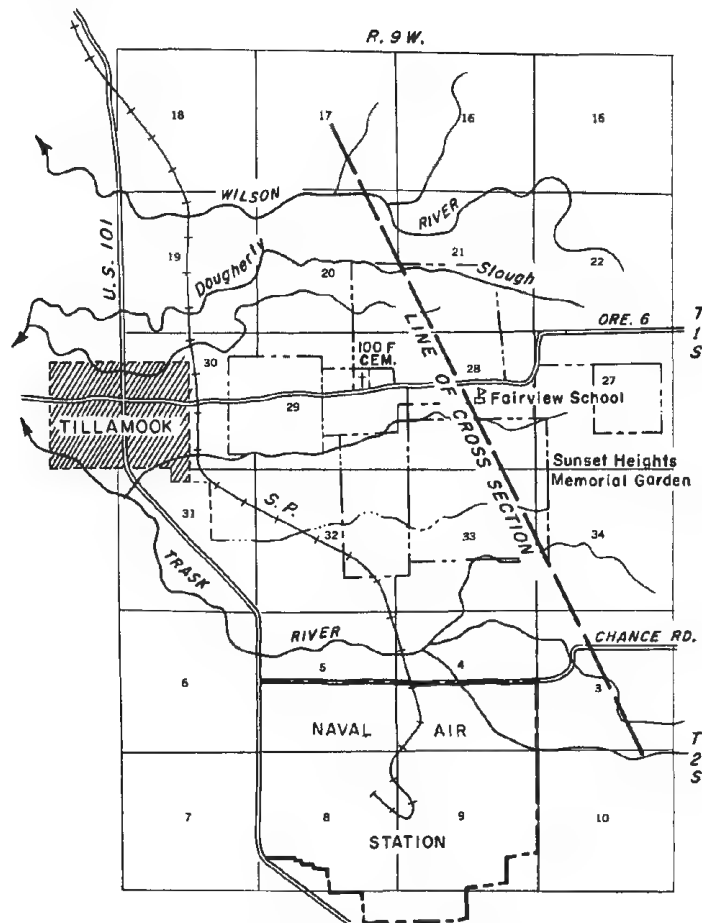


Figure 10.—Dashed line running from northwest to southeast is the location of topographic cross section shown in figure 9.

**Astoria silt loam, moderately deep, 40 to 60 percent slopes (AtG).**—This soil is on smoothly rolling and rough mountain slopes in the coast range. It is steeper than Astoria silt loam, 20 to 40 percent slopes. In addition, the soft, weathered shale is at a depth of 20 to 36 inches. Fragments of shale are generally numerous throughout the subsoil, and some fragments are scattered in the surface layer. The available water-holding capacity is moderate. Root penetration is limited by the shale. Runoff is medium to rapid, and the hazard of erosion is severe.

This soil is almost entirely in forests of Douglas-fir, hemlock, and red alder. (Capability unit VIIe-1; woodland suitability group 9.)

**Astoria silt loam, moderately deep, 20 to 40 percent slopes (AtF).**—This soil occupies the steep slopes of foothills along the coast range. It is similar to Astoria silt loam, 20 to 40 percent slopes, except that shale is at a depth of 20 to 36 inches. The available water-holding capacity is moderate. Root penetration is limited by the shale.

The soil is in forests of Douglas-fir, hemlock, and red alder. (Capability unit VIe-1; woodland suitability group 8.)



TABLE 5.—Total acreage and proportionate extent of the soils and the approximate percentage in various uses

Soil	Total	Proportionate extent	Crop-land	Pasture	Forest	Urban	Other uses
	<i>Acres</i>	<i>Percent</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>
Active dune land.....	3, 986	2. 8	5	0	273	3, 489	219
Astoria silt loam, 3 to 12 percent slopes.....	2, 368	1. 7	771	255	1, 229	113	0
Astoria silt loam, 12 to 20 percent slopes.....	3, 195	2. 2	631	314	2, 183	67	0
Astoria silt loam, 20 to 40 percent slopes.....	24, 037	16. 9	812	488	22, 445	292	0
Astoria silt loam, 40 to 60 percent slopes.....	19, 949	14. 1	87	78	19, 776	8	0
Astoria silt loam, moderately deep, 20 to 40 percent slopes.....	175	. 1	0	0	174	0	1
Astoria silt loam, moderately deep, 40 to 60 percent slopes.....	570	. 4	14	17	539	0	0
Brallier peat.....	236	. 2	58	82	53	12	31
Brenner silt loam.....	3, 311	2. 3	2, 699	206	386	20	0
Chitwood silt loam, 0 to 7 percent slopes.....	1, 668	1. 2	1, 210	112	333	13	0
Chitwood silt loam, 7 to 12 percent slopes.....	119	. 1	75	7	37	0	0
Coquille and Brenner silt loams.....	6, 264	4. 4	4, 155	836	1, 028	214	31
Gardiner fine sandy loam, 0 to 3 percent slopes.....	404	. 3	316	14	36	38	0
Gardiner fine sandy loam, overwashed, 3 to 7 percent slopes.....	298	. 2	298	0	0	0	0
Gauldy loam, 0 to 7 percent slopes.....	1, 220	. 9	883	48	285	4	0
Gauldy loam, shallow, 0 to 7 percent slopes.....	380	. 3	251	24	105	0	0
Ginger silt loam, 0 to 7 percent slopes.....	1, 170	. 8	915	40	54	156	5
Hebo silty clay loam, 0 to 3 percent slopes.....	2, 580	1. 8	0	1, 662	273	165	480
Hembre silt loam, 3 to 12 percent slopes.....	732	. 5	140	182	410	0	0
Hembre silt loam, 12 to 20 percent slopes.....	588	. 4	112	47	429	0	0
Hembre silt loam, 20 to 40 percent slopes.....	4, 197	3. 0	91	142	3, 964	0	0
Hembre silt loam, 40 to 60 percent slopes.....	24, 279	17. 1	216	58	23, 946	59	0
Hembre silt loam, moderately deep, 20 to 40 percent slopes.....	522	. 4	4	12	505	1	0
Hembre silt loam, moderately deep, 40 to 60 percent slopes.....	2, 861	2. 0	31	1	2, 829	0	0
Knappa silt loam, 0 to 7 percent slopes.....	4, 429	3. 1	3, 376	293	685	75	0
Knappa silt loam, 7 to 12 percent slopes.....	291	. 2	210	4	57	20	0
Knappa silt loam, moderately deep, 0 to 12 percent slopes.....	752	. 5	477	154	113	8	0
Made land.....	734	. 5	123	28	25	293	265
Meda gravelly loam, 3 to 12 percent slopes.....	1, 446	1. 0	1, 209	26	209	0	2
Meda gravelly loam, 12 to 20 percent slopes.....	226	. 2	209	0	17	0	0
Nehalem silt loam, 0 to 3 percent slopes.....	8, 695	6. 1	8, 155	237	242	61	0
Nehalem silt loam, overwashed, 3 to 7 percent slopes.....	173	. 1	173	0	0	0	0
Neskowin silty clay loam, 12 to 20 percent slopes.....	362	. 3	231	53	78	0	0
Neskowin silty clay loam, 20 to 40 percent slopes.....	679	. 5	77	88	514	0	0
Neskowin silty clay loam, 40 to 60 percent slopes.....	495	. 3	144	261	88	0	2
Nestucca silt loam.....	1, 539	1. 1	1, 270	142	76	51	0
Netarts fine sandy loam, 7 to 30 percent slopes.....	1, 549	1. 1	23	7	1, 266	163	90
Quillayute silt loam, 0 to 7 percent slopes.....	3, 557	2. 5	2, 642	22	93	800	0
Quillayute silt loam, moderately deep, 0 to 12 percent slopes.....	178	. 1	150	0	2	26	0
Riverwash.....	381	. 3	55	0	57	0	269
Rock land.....	49	( <sup>1</sup> )	0	0	43	0	6
Tidal flats.....	1, 280	. 9	106	0	19	6	1, 149
Winema silt loam, 3 to 12 percent slopes.....	440	. 3	327	23	41	49	0
Winema silt loam, 12 to 20 percent slopes.....	407	. 3	131	46	87	143	0
Winema silt loam, 20 to 40 percent slopes.....	1, 218	. 9	262	221	521	214	0
Winema silt loam, moderately deep, 12 to 20 percent slopes.....	275	. 2	262	1	12	0	0
Winema silt loam, moderately deep, 20 to 40 percent slopes.....	327	. 2	109	24	194	0	0
Yaquina loamy fine sand, 0 to 3 percent slopes.....	1, 237	. 9	423	158	457	199	0
Total soils mapped.....	135, 828	95. 8	33, 918	6, 413	86, 188	3, 489	5, 820
Water.....	6, 092	4. 3					
Total survey area.....	141, 920	100. 0					

<sup>1</sup> Less than 0.1 percent.

## Brallier Series

In the Brallier series are very poorly drained, very strongly acid to extremely acid soils that consist mainly of slightly decomposed, fibrous organic material. The soils have formed mainly from the remains of water-loving plants. They occupy nearly level basins a little above sea level. Most areas are on tideland; some are in depressed areas along sluggish streams near tideland. Associated with the Brallier soils are those of the Coquille, Brenner, and Yaquina series. The vegetation

is mainly brush, willow, and spruce.

The surface soil is dark-brown peat that has no evident structure. The subsoil is dark grayish-brown or yellowish-brown, partly decomposed roots, twigs, reeds, and sedges. The underlying material in most places is very dark gray sand, but in places it is marine mud.

Some areas of the Brallier soils have been drained and are used for pasture and forage crops. In addition, there are one or two areas of small acreage in cranberries and blueberries. There is some commercial harvest of peat moss.



Figure 11.—Pedestals of Astoria soil, 2 to 3 inches high. These are the result of erosion caused by runoff and the pounding of rain.

**Brallier peat (Bp).**—This soil is in basins and depressions that are a little above sea level. The water table is at or near the surface most of the time.

**Profile description:**

**Surface soil—**

0 to 3 inches, dark-brown peat (brown and soft, dry) consisting of 50 percent raw residue of forest litter, spongy moss, and woody material and 30 percent of live roots.

3 to 6 inches, dark grayish-brown peat, 70 percent of which consists of fibrous, undecomposed remains and roots of alder, broadleaf maple, and other water-loving plants; no discernible structure; extremely acid.

**Subsoil—**

6 to 24 inches, grayish-brown peat, consisting of fine fibrous decomposed material containing roots, reeds, and twigs and coarse fragments of wood; no structure; extremely acid.

24 to 38 inches, dark grayish-brown and yellowish-brown, partly decomposed, fibrous remains of sedge and reed; strongly acid.

38 to 48 inches, very dark grayish-brown mixture of muck and undecomposed woody and fibrous vegetation; slightly acid.

**Substratum—**

48 to 60 inches +, gray muck, 20 percent of which consists of the remains of woody and fibrous vegetation; slightly acid.

The underlying material occurs at variable depths. In some places it is very dark-gray sand, and in others it is gray marine mud.

The profile contains intermittent layers of muck, fibrous peat, raw peat, and thin mineral material. All of these layers are variable in thickness and in depth from the surface.

Included with Brallier peat are several small spots of sphagnum moss peat that occur in association with the Yaquina soils near Sand Lake.

Root penetration in Brallier peat depends on the height of the water table. The available water-holding capacity is low; subsoil permeability is moderately rapid. Run-off is very slow, and there is no erosion hazard. The soil is low in fertility and ranges from very strongly acid to extremely acid.

Most of the acreage of this soil is still in native vegetation. Where diked and drained, the soil is used for shallow-rooted pasture grasses and legumes, and for cranberries, blueberries, and other specialty crops. (Capability unit IVw-3; woodland suitability group 17.)

## Brenner Series

The Brenner series consists of poorly drained, strongly acid soils on bottom lands. The soils are in the lowest part of the flood plain, or in swales, adjacent to the terraces or uplands. The Brenner soils have formed in alluvial deposits consisting of fine-textured silt and clay. The Brenner soils are associated chiefly with the Nehalem and Nestucca soils. Floods occasionally leave thin layers of fresh alluvium on the surface. Water ponds in winter after heavy rains or when streams overflow. The vegetation is mainly alder and hemlock, with a dense understory of shrubs and water-tolerant plants.

The surface soil is very dark grayish brown. It has faint stains and mottles of reddish brown and is friable and granular. The subsoil is dark grayish-brown, prominently mottled with yellowish-red, firm silty clay having subangular blocky structure. The underlying material is dark greenish-gray, massive silty clay. The remains of partly decayed plants, tree roots, and rotted logs occur throughout the soil profile. Where the Brenner soils are transitional to the Nestucca soils, the surface layer may be free of mottles.

Most of the acreage of the Brenner soils has been drained and is used for pasture, hay, and silage. A small acreage is still in forest.

**Brenner silt loam (Br).**—This soil occurs on bottom lands next to streams.

**Representative profile observed in an undrained area:**

**Surface layer—**

0 to 7 inches, very dark grayish-brown, friable (grayish-brown and soft, dry) silt loam; faint mottles of reddish brown; granular structure.

7 to 13 inches, very dark grayish-brown, friable silty clay loam; distinct mottles of brown and yellowish red; subangular blocky structure; sticky and plastic when wet.

**Subsoil—**

13 to 21 inches, dark grayish-brown, firm silty clay loam; prominent mottles of yellowish red; subangular blocky structure; sticky and plastic when wet.

21 to 31 inches, dark grayish-brown, firm silty clay; prominent mottles of yellowish red; subangular blocky structure; sticky and plastic when wet.

31 to 40 inches, dark-gray, firm silty clay; prominent mottles of brown and gray; blocky structure; sticky and plastic when wet.

**Substratum—**

40 inches +, dark greenish-gray silty clay; massive; sticky and plastic when wet; distinct odor of hydrogen sulfide.

The main variation is that the dark-gray silty clay is 24 to 40 inches from the surface; the average depth of this layer is about 24 inches. In some areas the surface

soil is light silty clay loam. A few small areas have a thin overwash of recently deposited silty alluvium. Included with this soil are small areas of the Nestucca and the Brallier soils.

Natural drainage is poor, runoff is very slow, and subsoil permeability is moderately slow. The available water-holding capacity is moderate to high; root penetration is moderately deep. The soil is strongly acid and medium in fertility. There is little or no erosion hazard.

Nearly all of this soil is used for hay and pasture. Some of the acreage has been drained, but much of it still needs drainage. Some cropped areas are irrigated by sprinklers. (Capability unit IIIw-1; woodland suitability group 5.)

## Chitwood Series

The Chitwood series consists of deep, nearly level to strongly sloping, imperfectly drained soils. The soils occupy depressions on slopes and on nearly level terraces and swalelike seeps on the moderately sloping foothills. They formed in old alluvium derived from shale. Chitwood soils are scattered throughout the valleys of the Tillamook survey area and are associated with the Knappa, Astoria, and Hebo soils. The original vegetation was Douglas-fir, hemlock, and cedar.

The surface layer is very dark grayish brown, friable, and granular. The subsoil is dark brown to dark yellowish brown, mottled with strong brown to yellowish brown, and is firm and blocky. In places soft, weathered pebbles occur in the substratum. Because of restricted drainage, the lower subsoil and substratum have noticeable graying in many places.

Chitwood soils are used mainly for pasture and forage crops; some small acreages are in timber.

**Chitwood silt loam, 0 to 7 percent slopes (ChB).**—This soil is in nearly level and gently sloping depressions on terraces.

Representative profile observed in a grass pasture:

### Surface layer—

0 to 11 inches, very dark grayish-brown, friable (grayish-brown and slightly hard, dry) silt loam; granular structure.

### Subsoil—

11 to 19 inches, dark-brown, firm silty clay loam; subangular blocky structure; sticky and plastic when wet.

19 to 29 inches, dark yellowish-brown, firm silty clay; many mottles of strong brown; subangular blocky structure; sticky and plastic when wet.

29 to 34 inches +, dark yellowish-brown, firm silty clay loam; coarse mottles of strong brown and yellowish red; angular or subangular blocky structure; sticky and plastic when wet.

The chief variation is in the color of the subsoil, which ranges from dark yellowish brown to dark grayish brown and in some areas to dark gray. The color varies because some areas have more seepage and more restricted drainage than other areas. The subsoil also has prominent mottles of strong brown, yellowish red, and reddish yellow. The substratum, mainly on terraces, contains soft, weathered pebbles.

Included with this soil are small areas of the poorly drained Hebo and of the well-drained Astoria and Knappa soils.

Natural drainage is imperfect, and runoff is slow to medium; subsoil permeability is slow. The available water-holding capacity is moderate to high; root penetration is moderately deep. There is a slight erosion hazard. The soil is medium in fertility and in organic matter and is very strongly acid.

This soil is used mainly for the production of pasture, hay, and silage. Most areas have been cleared, and much of the acreage has been drained. Many areas still need drainage, and some areas are still forested with Douglas-fir, Sitka spruce, western hemlock, western red-cedar, and red alder.

Use of this soil for crops is restricted by lack of drainage. Cropped areas need supplemental fertilization. Some of them are irrigated through sprinklers to improve yields. (Capability unit IIw-1; woodland suitability group 5.)

### Chitwood silt loam, 7 to 12 percent slopes (ChC).—

This soil occupies the sloping, concave positions on foothills and on foot slopes. Only a small acreage of this soil is in the Tillamook survey area. Restricted drainage of this soil is the result of seepage from higher lying areas. This soil is similar to Chitwood silt loam, 0 to 7 percent slopes, except for slopes. The hazard of erosion is slight; runoff is medium.

Included with this soil are small areas of the poorly drained Hebo and the well-drained Astoria soils on uplands and of Knappa soils on the terraces.

Chitwood silt loam, 7 to 12 percent slopes, is used for pasture, hay, and timber. Some areas have been drained and are irrigated through sprinklers. (Capability unit IIIw-2; woodland suitability group 5.)

## Coquille Series

The Coquille series consists of very poorly drained, very strongly acid soils on nearly level bottom lands and stream deltas along coastal tideland. These soils are subject to tidal overflow, and if not protected by dikes, most areas would be covered by high tides. The overflow deposits fresh alluvium in undiked areas. The Coquille soils are associated with the Tidal flats land type and with soils of the Brenner and the Brallier series.

The Coquille soils formed in deep deposits of dark-gray alluvial and tidewater sediment that washed from shale, sandstone, and coarse- and fine-grained igneous rocks. The surface has a microrelief consisting of numerous depressions, small ridges, stream channels, and sloughs. Profile layers may differ within short distances because of frequent changes in the channels of rivers and sloughs and in the kinds of materials in the deposits. Continued saturation gives the Coquille soils a high degree of mottling and some iron stains. The vegetation is mainly rushes, marsh grasses, sedges, and tules.

The surface soil is very dark grayish brown, highly mottled and stained with strong brown, and is friable and granular. The subsoil is dark grayish-brown silty clay loam with numerous mottles of strong brown. In addition, it is firm and has subangular blocky structure. The subsoil is underlain at a depth of 30 to 40 inches by very dark-gray to bluish-gray, massive, silty clay marine sediment. Layers of peat are in the profile; sandy layers may occur locally. The various layers are mainly the

result of different deposits of material and of the varying length of periods that these materials have weathered.

Under natural conditions, the Coquille soils produce a limited amount of swamp-grass pasture. When diked and drained, they produce excellent domestic grasses for hay, silage, or pasture.

In the Tillamook survey area, the Coquille soils are mapped as an undifferentiated unit with the Brenner soils.

**Coquille and Brenner silt loams (Co).**—This undifferentiated mapping unit occupies nearly level tidelands, flat stream deltas, and bottom lands subject to tidewater overflow. When unprotected by dikes, this mapping unit is flooded by tides. It consists of about 70 percent Coquille silt loam and 30 percent Brenner silt loam, but the percentage of these soils in any individual area may vary considerably from this. The Brenner soil in this mapping unit is similar to the Brenner soil described under the Brenner series.

Representative profile of Coquille silt loam observed in a pasture of mixed native and tame grasses:

**Surface layer—**

0 to 6 inches, very dark grayish-brown, friable (grayish-brown and soft, dry) silt loam; granular structure; numerous large brown stains.

6 to 13 inches, dark grayish-brown, friable silt loam; many large mottles of strong brown and yellowish red; granular structure; sticky and slightly plastic when wet.

**Subsoil—**

13 to 19 inches, dark grayish-brown, firm silty clay loam; many faint mottles of strong brown; very large amount of fibrous organic material.

19 to 40 inches, dark grayish-brown, firm silty clay loam; common, faint mottles of strong brown and light yellowish brown; subangular blocky structure; sticky and plastic when wet; accumulations of yellow sulfide noticeable.

**Substratum—**

40 to 60 inches +, very dark gray silty clay; massive; sticky and plastic when wet; very strongly acid; has a somewhat bluish-gray cast when first removed from this depth.

The chief variations are in the amount of organic matter and in the depth and thickness of the various soil layers. The surface probably remained stable from time to time, long enough for a surface layer containing organic matter to be developed; then that surface layer was covered by new sediment. Some small areas have a surface layer of silty clay loam. Other areas have thin, stratified layers of fibrous peat. In a few small areas, the profile rests on fibrous peat. Depth to non-conforming clayey marine sediment ranges from 24 to 40 inches.

Included with this mapping unit are small areas of poorly drained Brallier peat and Tidal flats.

Natural drainage is very poor. When not protected by adequate dikes or levees and tide gates, these soils are ponded during high tides. The available water-holding capacity is moderate to high. Root penetration is moderately shallow. The soils are very strongly acid and low in fertility. Accumulations of sulfide are throughout the profile, and they are more numerous in the lower subsoil.

This mapping unit has been cleared and diked. When diked and drained, most areas are used for pasture and forage crops. Ditches and tile drains are needed for best production of deep-rooted grasses and legumes.

Outlets for drains are regulated by tide gates, which open at low tide and are closed by the high tide. Some drained areas in crops are irrigated through sprinklers. The cropped areas need fertilizer. (Capability unit IVw-1; woodland suitability group 2.)

## Gardiner Series

The Gardiner series consists of deep, well-drained, coarse-textured soils on bottom lands. The soils have formed in loose, sandy alluvium. They occur in narrow strips near the banks of the large streams and in the sharp bends of streams. The Gardiner soils are associated with the Nehalem, Gauldy, and Nestucca soils. Individual areas of Gardiner soils are small, and the total acreage in the Tillamook survey area is small. The original vegetation was trees and shrubs.

The surface soil is dark brown and very friable and has weak, subangular blocky structure. The underlying material consists of layers of dark yellowish-brown loamy sand, fine sand, and sand. The sandy layers vary in thickness. Some areas of Gardiner soils are subject to damaging overflow, which causes erosion and which also deposits sand, silt, and debris. These soils are used almost exclusively for pasture and hay.

**Gardiner fine sandy loam, 0 to 3 percent slopes (GaA).**—This soil occurs on nearly level bottom lands adjacent to the major streams.

Representative profile observed in a pasture:

**Surface layer—**

0 to 8 inches, dark-brown, very friable (dark grayish-brown and soft, dry) fine sandy loam; weak, subangular blocky structure.

**Subsoil—**

8 to 34 inches, dark yellowish-brown loamy fine sand; very weak, coarse, subangular blocky structure.

**Substratum—**

34 to 60 inches +, strata of varying thickness consisting of variegated brown loamy sand, fine sand, and sand.

The main variation is in the thickness of the surface layer. In some places this layer is as much as 18 inches thick. Recent deposits of coarse sediment are on the surface in many places.

Included in this unit are small areas having a gravelly subsoil, and small areas of Gauldy loam and Nehalem silt loam. Very small areas of moderately well drained Nestucca soils are also included.

The soil is rapidly permeable, strongly acid, moderately fertile, and medium in organic matter. The hazard of erosion is slight. Roots can penetrate deeply. The available water-holding capacity is moderate to low.

Much of the soil is in grasses and legumes that are harvested for hay, pasture, or silage. These crops need fertilizer. Most cropped areas are irrigated through sprinklers. (Capability unit IIS-1; woodland suitability group 1.)

**Gardiner fine sandy loam, overwashed, 3 to 7 percent slopes (GdB).**—This soil generally occurs in sharp bends of the major rivers, and it is subject to damaging overflow during periods of high water. The surface is irregular and hummocky and marked by many old stream channels. It is similar to Gardiner fine sandy loam, 0 to 3 percent slopes, except that most areas have some recently deposited sand on the surface. Runoff is slow, and the hazard of erosion is moderate. The over-



flowing current scours away the soil and the banks, and in places it deposits sand, silt, and debris on the surface.

Nearly all of this soil is used for hay and pasture. Most areas in these crops are irrigated through sprinklers. (Capability unit IVE-2; woodland suitability group 17.)

## Gauldy Series

The Gauldy series consists of somewhat excessively drained, shallow to moderately deep, gravelly alluvium. The soils generally occupy narrow flood plains of the Miami and Kilchis Rivers and other very active, fast-flowing streams. They are young soils over sand and gravel and have only a weakly developed profile. The Gauldy soils are associated mainly with the Nehalem, Brenner, and Gardiner soils on bottom lands and with the Knappa and Meda soils on low terraces and foothills. The shallow Gauldy soils are associated with Riverwash. The original vegetation was hemlock, Douglas-fir, Sitka spruce, red alder, and willow.

The surface soil is dark brown, very friable, and subangular blocky. The subsoil is dark yellowish brown and very friable and has a weak, subangular blocky structure. Waterworn pebbles occur throughout the profile. The soils are underlain at varying depths by gravelly and stony strata.

The Gauldy soils are used chiefly for pasture and hay. Some small acreages are still in native vegetation.

**Gauldy loam, 0 to 7 percent slopes (GmB).**—This soil occupies bottom land where the surface has been cut by old stream channels.

Representative profile observed in an area of grass:

### Surface layer—

0 to 8 inches, dark-brown, very friable (dark grayish-brown and soft, dry) loam; subangular blocky structure; 10 percent of volume is gravel of medium size.

### Subsoil—

8 to 26 inches, dark yellowish-brown, friable loam; weak, subangular blocky structure; 15 percent of volume is gravel of medium size.

26 to 38 inches, dark yellowish-brown, very friable, gravelly loamy coarse sand; weak, subangular blocky structure.

38 to 55 inches, dark yellowish-brown, friable loamy fine sand; weak, subangular blocky structure; 10 percent of volume is gravel of fine size.

### Substratum—

55 inches +, waterworn coarse sand and gravel.

The chief variations are in the moderate to strong grade of structural development in the surface and sub-surface layers and in the amount of gravel throughout the profile. In addition, the type of underlying sediment ranges from gravelly silt, fine sand, and sand to coarse sand, stones, and boulders. In some places the surface layer is silt loam.

Included with this soil are small areas of Nehalem and Gardiner soils and of the imperfectly drained Brenner soils on bottom lands. Very small areas of the Knappa and Meda soils on fans are also included.

Runoff is slow. Subsoil permeability is moderately rapid. The available water-holding capacity is moderate to low; root penetration is moderately deep to deep. The hazard of erosion is slight, but some damaging overflow occurs. The soil is medium in organic matter and fertility and is strongly acid.

Much of this soil is used for pasture and hay. These crops need fertilizer and are irrigated through sprinklers. (Capability unit IIs-1; woodland suitability group 1.)

**Gauldy loam, shallow, 0 to 7 percent slopes (GsB).**—This soil has an irregular, hummocky surface. It occupies narrower upstream bottom lands than Gauldy loam, 0 to 7 percent slopes, and the underlying coarse-textured alluvial sediment is only 6 to 8 inches from the surface. Some places have gravelly loam surface soil.

Included with this soil are small areas of Riverwash and very small areas of very gravelly Meda soil.

Subsoil permeability is rapid. The available water-holding capacity is very low. Root penetration is shallow. The hazard of erosion is moderate, and some damaging overflow occurs. The soil is low in organic matter and in natural fertility.

Over two-thirds of the acreage of this soil is used for pasture and hay. All areas in these crops are irrigated through sprinklers. (Capability unit VIIs-1; woodland suitability group 17.)

## Ginger Series

The Ginger series consists of deep, imperfectly drained, fine-textured soils on stream terraces in the Fairview and Idaville localities. The Ginger soils occupy concave positions on nearly level to gentle slopes between the higher lying Quillayute soils and the lower lying Hebo soils in depressions or swales. Ginger soils are associated with the Meda, Quillayute, and Hebo soils. The parent material is old valley fill that originated from sedimentary and igneous rocks. The original vegetation was forests of spruce and hemlock.

The surface soil is black, very friable, and granular. The subsoil is dark grayish brown to grayish brown, firm, and blocky. The subsoil is strongly mottled with yellowish red and grayish brown. Under the subsoil, at varying depths, are discontinuous layers of compacted gravel. In some places the layers of gravel may be within 24 inches of the surface. On the average, however, gravel is at a depth of 30 to 60 inches.

Most areas of the Ginger soils are under a permanent cover of grass and legumes that is harvested for hay, pasture, or silage. Small areas are still in native vegetation.

**Ginger silt loam, 0 to 7 percent slopes (G+B).**—This soil is on terraces adjacent to the uplands.

Representative profile observed in a grass pasture:

### Surface layer—

0 to 17 inches, black, very friable (very dark gray and soft, dry) silt loam; granular structure; nonsticky and slightly plastic when wet.

### Subsoil—

17 to 20 inches, very dark grayish-brown silty clay loam; few, faint mottles of yellowish brown; firm, sticky, and plastic when wet; blocky structure.

20 to 28 inches; dark grayish-brown, firm silty clay; common, distinct mottles of strong brown; sticky and plastic when wet; blocky structure.

28 to 38 inches, grayish-brown, firm silty clay; many prominent mottles of yellowish red; sticky and plastic when wet; blocky structure.

38 to 52 inches, grayish-brown, firm silty clay; many prominent mottles of yellowish red; sticky and plastic when wet; blocky structure; numerous weathered and partly decomposed pebbles.

### Substratum—

52 to 60 inches +, compacted gravel.

The chief variation is in the depth to compacted gravel. In more than 85 percent of the area, compacted gravel is more than 3 feet below the surface. This soil is generally nearly level, but small gently sloping areas are included. Other soils included with Ginger silt loam, 0 to 7 percent slopes, are the Meda, Quillayute, and Hebo soils.

Natural drainage is imperfect. Runoff and permeability are slow. The available water-holding capacity is moderate to high; the penetration of roots is moderately deep. The hazard of erosion is slight. The soil is very high in organic matter, moderately low in fertility, and very strongly acid.

Ginger silt loam, 0 to 7 percent slopes, is used for pasture and hay crops. Most of the acreage has been drained through the use of open ditches or closed tile drains. Both kinds of drainage are used in some areas. Crops respond well to fertilizer. Some areas in crops are irrigated through sprinklers. (Capability unit IIw-1; woodland suitability group 5.)

## Hebo Series

The Hebo series consists of poorly drained, fine-textured, very strongly acid soils. The soils are mainly in nearly level or slightly depressed positions on stream terraces, and in depressions on the bottoms of small valleys. They formed in deep, fine-textured alluvium that washed chiefly from shale. Floods and runoff from higher areas occasionally deposit fresh layers of alluvium on the surface. During the wet season, the Hebo soils are waterlogged. They occur in association with the Quillayute, Knappa, Chitwood, and Ginger soils. The native vegetation consists mainly of sedge, skunkcabbage, willow, and spruce.

The Hebo soils are the only claypan soils in the Tillamook survey area. Their surface soil is firm, granular, and very dark gray or dark brown to almost black. The subsoil is very firm, prismatic and blocky clay that is dark gray to gray and highly mottled with brown and gray. Near Hemlock, the Hebo soils are covered by 4 to 12 inches of brown, medium-textured alluvium. Some areas of the Hebo soils are naturally better drained than others because of their more favorable position on the landscape. Hebo soils on sloping terraces are less waterlogged during the dry season than those in depressions.

Most Hebo soils are used for hay and pasture. Yields of forage are low because drainage is poor. Yields can be improved by draining the soil and applying fertilizer.

**Hebo silty clay loam, 0 to 3 percent slopes (HbA).—** This soil occurs in concave areas on fans and terraces adjacent to uplands.

Representative profile observed in an undrained area:

### Surface layer—

0 to 4 inches, very dark gray to almost black, firm (dark gray and slightly hard, dry) silty clay loam; granular structure; sticky and plastic when wet.

4 to 10 inches, very dark gray, very firm silty clay; numerous mottles of reddish brown; blocky structure; sticky and very plastic when wet.

### Subsoil—

10 to 18 inches, dark-gray, very firm clay; many coarse mottles of strong brown; prismatic and blocky structure; very sticky and very plastic when wet.

18 to 28 inches, gray, very firm clay; many coarse mottles of strong brown; prismatic and blocky structure; very sticky and very plastic when wet.

28 to 35 inches, gray, dark-gray, and strong-brown, firm silty clay; blocky structure; sticky and very plastic when wet; some weathered, waterworn pebbles and cobbles.

### Substratum—

35 to 42 inches +, olive-gray, strong-brown, and gray, massive clay mixed with numerous weathered and decomposed pebbles and cobbles.

The surface layer is generally about 10 inches thick; but in some places that have received recent overwash, it is as much as 22 inches thick over clay. In a few places the subsoil is nearly massive.

Near the town of Hebo, several small areas of Hebo silty clay loam soil on terraces with slopes up to 4 percent are included. The soil on these slopes is somewhat better drained than that having less gradient, and it is not ponded. Also included are small patches of the Knappa or Meda soils.

Natural drainage is poor, runoff is very slow, and the subsoil clay is very slowly permeable. The available water-holding capacity is moderate to low; root penetration is shallow. The hazard of erosion is slight. The soil is low in fertility, high in organic matter, and very strongly acid.

Most areas of this soil have been cleared. Some areas have been drained by use of open ditches and tile, but most of the acreage has not been drained. Crops on some drained areas are irrigated through sprinklers. Tussocks are always in undrained pasture, because grasses offer them very little competition (fig. 12). (Capability unit IVw-2; woodland suitability group 5.)

## Hembre Series

The Hembre series consists of deep to moderately deep, well-drained, strongly acid to very strongly acid soils. The soils occupy positions that range from gently sloping foothills to very steep mountains in the coast range. They have developed mainly from basic igneous rocks. The Hembre soils are closely associated with the Neskowin soils near the communities of Oretown and Neskowin and with the Knappa and Hebo soils. Neskowin soils generally occupy fern-covered slopes adjacent to the coast. The Hembre and Astoria soils make up nearly all the soils on uplands in the Tillamook survey area. The vegetation is mainly Douglas-fir, hemlock, alder, fern, and salal.

The surface soil is dark reddish brown, friable, and granular; the subsoil is reddish brown, firm, and sub-angular blocky. In most places the profile contains a large amount of cobblestones and gravel. In some places the lower subsoil is more than 50 percent stones. In most areas the subsoil is underlain by weathered and broken hard rock. The Hembre soils on gentle slopes have deeper profiles and contain fewer stones than those on steeper slopes.

The Hembre soils are mainly in forests in which Douglas-fir and hemlock are the most valuable species. The gently sloping Hembre soils on foothills along the valleys are used for pasture and hay.



Figure 12.—The open ditch helps to drain an area of Hebo soils. The tussocks shown on right side of photograph are growing on imperfectly drained Chitwood soil.

**Hembre silt loam, 20 to 40 percent slopes (HeF).—**  
This soil occupies slopes above the valley foothills.

Representative profile in a logged area:

**Surface layer—**

0 to 11 inches, dark reddish-brown, friable (dark brown and soft, dry) silt loam; granular structure.

11 to 17 inches, dark-brown, friable silt loam; granular structure; slightly sticky and plastic when wet.

**Subsoil—**

17 to 29 inches, reddish-brown, firm silty clay loam; subangular blocky structure; sticky and plastic when wet; approximately 35 percent of layer consists of small stones.

29 to 38 inches, reddish-brown, firm very stony silty clay loam; subangular blocky structure; sticky and plastic when wet; approximately 60 percent of layer consists of small stones.

**Substratum—**

38 inches +, broken, igneous rock.

The chief variation is in the depth to igneous rock and in the amount of small, angular, broken stones in the profile. Texture ranges from silt loam to light silty clay loam, but silt loam predominates. The subsoil ranges from reddish brown to dark brown and in places is yellowish brown.

Included in this mapping unit are small areas of Astoria soils on the lower slopes.

Natural drainage is good, runoff is medium, and permeability is moderate. The available water-holding capacity is moderate to high. Root penetration is deep. The hazard of erosion is moderate. The soil is medium in fertility, moderately high in organic matter, and strongly to very strongly acid. There are a few small concretions of iron and manganese throughout the profile.

Nearly all of this soil is in natural vegetation consisting of hemlock and Douglas-fir forest. Production is higher than on any other forested soil in the Tillamook survey area. (Capability unit VIe-2; woodland suitability group 11.)

**Hembre silt loam, 40 to 60 percent slopes (HeG).—**

This soil is similar to Hembre silt loam, 20 to 40 percent slopes, except that the slopes are very steep and mountainous. Runoff is rapid, and the hazard of erosion is severe. Included with this soil are a few small areas of Rock land. Hembre silt loam, 40 to 60 percent slopes, is the most extensive soil in the Tillamook survey area. It is all in forests of hemlock and Douglas-fir. (Capability unit VIIe-2; woodland suitability group 12.)

**Hembre silt loam, moderately deep, 40 to 60 percent slopes (HmG).**—This soil is similar to Hembre silt loam, moderately deep, 20 to 40 percent slopes, except that on convex slopes it tends to be shallower and in some local areas it is less than 20 inches thick over hard rock. Rock outcrops are included with this soil.

Runoff is rapid, and the erosion hazard is severe. The soil is all in forests of hemlock and Douglas-fir. Slope and shallow soil restrict tree growth. (Capability unit VIIe-2; woodland suitability group 12.)

**Hembre silt loam, 3 to 12 percent slopes (HeC).**—This soil is similar to Hembre silt loam, 20 to 40 percent slopes. In most places it is 60 inches or more thick and has only a few stones in the profile. The hazard of erosion is slight. A few small areas of Knappa and Hebo soils are included. About half the acreage of this soil is used mainly for hay and pasture. Moderate yields are obtained if fertilizer is applied. (Capability unit IIIe-1; woodland suitability group 10.)

**Hembre silt loam, 12 to 20 percent slopes (HeD).**—This soil is like Hembre silt loam, 20 to 40 percent slopes, except that it generally has a deeper, less stony profile. Hard igneous rock generally is 50 to 60 inches below the surface. The erosion hazard is moderate. Part of this soil is in a permanent cover of grasses and legumes that are harvested for pasture or hay. (Capability unit IVe-1; woodland suitability group 10.)

**Hembre silt loam, moderately deep, 20 to 40 percent slopes (HmF).**—This soil differs from Hembre silt loam, 20 to 40 percent slopes, in having only a moderately deep profile over bedrock and not so much development of structure. Generally the soil consists of more than 50 percent stones and is 25 to 30 inches thick over hard rock. Root penetration is moderately deep; the available water-holding capacity is moderate. The hazard of erosion is moderate. Nearly all of this soil is in forest. Hemlock and Douglas-fir are the most important species. (Capability unit VIe-2; woodland suitability group 11.)

## Knappa Series

The Knappa series consists of well-drained, moderately deep to very deep, nearly level to strongly sloping soils on terraces along the sloping foothills. The Knappa soils formed in deep old valley fill (alluvium) that originated mainly from shale and some basic igneous rock. They are associated with the Astoria, Quillayute, Chitwood, and Hebo soils and are the most extensive soils on valley slopes in the Tillamook survey area. The original vegetation was Douglas-fir, hemlock, and alder.

The surface soil is very dark brown, friable, and granular. The subsoil is dark brown to dark yellowish brown, firm, and subangular blocky. The substratum in many places contains numerous weathered and partly decomposed pebbles.

The Knappa soils are used mainly for grasses and legumes harvested for pasture, hay, and silage. Only a few acres on the stronger slopes are not cleared. Where water is available, supplemental irrigation is applied through sprinklers to improve the yields of crops.

**Knappa silt loam, 0 to 7 percent slopes (KaB).**—This soil is on nearly level and very gently sloping terraces between the upland and the flood plain. The substratum

generally contains numerous small stones and pebbles. Representative profile observed in a grass pasture:

### Surface layer—

0 to 14 inches, very dark brown, friable (dark brown and soft, dry) silt loam; granular structure; few concretions of iron and manganese.

### Subsoil—

14 to 27 inches, dark-brown, firm silty clay loam; subangular blocky structure; sticky and plastic when wet.

27 to 48 inches, dark yellowish-brown, firm silty clay loam; subangular blocky structure; sticky and plastic when wet.

48 to 60 inches +, dark yellowish-brown, firm silty clay loam; subangular blocky structure; slightly sticky and plastic when wet; some weathered and partly decomposed pebbles.

The chief variations are in the color of the subsoil, which ranges from dark brown to yellowish brown, and in the amount and depth to gravel in the substratum. Layers of gravel are not present, but pebbles may be numerous and in places are within 40 inches of the surface.

Mapped with this soil are small areas of the Quillayute soils on terraces. Small areas of the Chitwood and Hebo soils are included in depressions.

Natural drainage is good, runoff is slow, and the hazard of erosion is slight. Subsoil permeability is moderate. The available water-holding capacity is high. Root penetration is very deep. The soil is medium in organic matter and in fertility and is very strongly acid.

This soil is used mainly for hay and pasture. These crops need supplemental fertilization to improve yields. Most areas are irrigated through sprinklers. (Capability unit IIe-1; woodland suitability group 3.)

**Knappa silt loam, moderately deep, 0 to 12 percent slopes (KmC).**—This soil differs from Knappa silt loam, 0 to 7 percent slopes, in that pebbles are very numerous in the lower substratum at a depth of 24 to 36 inches. As a rule, pebbles are scattered throughout the profile. The soil is somewhat droughty, and the available water-holding capacity is moderate. The depth to which roots can penetrate is limited by the underlying gravel. The main inclusions are small areas of gravelly Meda soils.

Knappa silt loam, moderately deep, 0 to 12 percent slopes, is used mainly for hay and pasture. These crops need fertilizer. Some of them are irrigated through sprinklers to improve yields. (Capability unit IIIe-1; woodland suitability group 3.)

**Knappa silt loam, 7 to 12 percent slopes (KaC).**—This soil is on the gently and strongly sloping terraces along foothills, and it differs but slightly from Knappa silt loam, 0 to 7 percent slopes. The profile is somewhat shallower over gravel. This soil includes areas of the Astoria, Meda, and Chitwood soils. It is used mainly for hay and pasture. These crops need supplemental fertilization. Some of them are irrigated through sprinklers to improve the yield. (Capability unit IIIe-1; woodland suitability group 3.)

## Made Land (Ma)

This unit consists of approximately 3 square miles of land leveled for a blimp base in the Second World War. Hills were cut and low areas filled to form a level surface consisting of heterogeneous material that originated from marine sediment, alluvial terraces, and recent alluvium.



This is the only large tract of Made land in the Tillamook survey area. It is now used mainly as an airport and for various industrial developments. (Capability unit VIIIc-1; woodland suitability group 18.)

### Meda Series

The Meda series consists of deep, well-drained, gently sloping to moderately steep soils on alluvial fans and foot slopes. The soils formed in unassorted material that sloughed and washed from residuum outcroppings of shale and occasionally mixed with igneous rocks. They are associated with the Knappa, Chitwood, Quillayute, and Ginger soils on terraces and with the Astoria and Hembre soils on uplands. The original vegetation was Douglas-fir, hemlock, red alder, and redcedar.

The surface soil is very dark grayish brown, friable, and granular. The subsoil is dark brown, friable, and subangular blocky. Pebbles, stones, and fragments of shale are on the surface and throughout the profile. Meda soils on the more recently deposited alluvial fans show the least textural and structural development.

Meda soils are used chiefly for hay and pasture. A small acreage is still in native vegetation.

**Meda gravelly loam, 3 to 12 percent slopes (MeC).**—This soil is on gently to strongly sloping foot slopes and fans.

Representative profile observed in a pasture:

Surface soil—

0 to 9 inches, very dark grayish-brown, friable (dark-brown and soft, dry) gravelly loam; granular structure; numerous fragments of coarse sand, gravel, and shale.

Subsoil—

9 to 24 inches, dark-brown, friable gravelly clay loam; subangular blocky structure; many fragments of coarse sand, gravel, and shale.

Substratum—

24 to 36 inches +, dark-brown sandy loam; massive; abundant fragments of coarse sand, gravel, and shale.

Many small stones are scattered throughout the profile. In some places, the soil is nearly free of coarse-textured material. As a rule, very little textural or structural development has occurred below the surface layer. In some places, the parent material is wholly from igneous rock, and in other places it is from shale.

Small areas of the Knappa, Chitwood, Quillayute, and Ginger soils are included with this soil.

Natural drainage is good, runoff is slow to medium, and permeability is moderate. As a rule, the available water-holding capacity is moderate, but it varies according to the quantity of stone and gravel in the profile. The depth of root penetration also varies according to the quantity of these materials. The hazard of erosion is slight. The soil contains moderate amounts of organic matter, is strongly acid, and is medium in fertility.

This soil is used mainly for pasture and hay. These crops require the use of fertilizer. Some areas in forage crops are irrigated through sprinklers. (Capability unit IIIc-1; woodland suitability group 3.)

**Meda gravelly loam, 12 to 20 percent slopes (MeD).**—This soil occupies moderately steep foot slopes and fans. It differs from Meda loam, 3 to 12 percent slopes, in having somewhat more stones and gravel. This soil includes small areas of the Astoria and Hembre soils. Runoff is medium, and the hazard of erosion is moderate.

This soil is used mostly for pasture and hay. These crops need fertilizer to produce good yields. Douglas-fir and hemlock are the most valuable forest trees on this soil. (Capability unit IVc-1; woodland suitability group 3.)

### Nehalem Series

The Nehalem series consists of well-drained, very deep, nearly level to gently sloping soils that occupy a large acreage of bottom lands. The Nehalem soils formed under forest in brownish, medium to moderately fine textured stream alluvium that washed from igneous and sedimentary rocks. They occur in association with the Gardiner, Nestucca, and Brenner soils. In places the surface is irregular because old, partly filled stream channels and swales are in the area.

The surface layer is very dark grayish-brown, very friable, granular silt loam. The subsoil is dark-brown, firm silt loam or silty clay loam with subangular blocky structure. In places recently deposited overwash consisting of coarse-textured, sandy layers occurs on and in the soil.

Some undulating and low areas next to fast-flowing streams are subject to damaging overflow during winter storms. This overflow deposits from ½ inch to 10 inches of silt and sand on the surface. In these areas, the fast-flowing current may scour out pits and may leave brush and logging debris scattered over the surface.

The Nehalem soils are used for pasture and forage crops. Most areas have been cleared.

**Nehalem silt loam, 0 to 3 percent slopes (NaA).**—This is the most extensive cropland soil in the Tillamook survey area. It occupies nearly level, well-drained bottom lands adjacent to the Nestucca, Brenner, and Gardiner series.

Representative profile observed in a pasture of tame grasses:

Surface layer—

0 to 17 inches, very dark grayish-brown, very friable (brown and soft, dry) silt loam; granular; strongly acid.

Subsoil—

17 to 37 inches, dark-brown, firm silty clay loam; very fine, subangular blocky structure; slightly sticky and plastic when wet; very strongly acid.

37 to 60 inches +, dark-brown, firm silty clay loam; very fine, blocky structure; sticky and plastic when wet; very strongly acid.

The chief variations are in stratification of the profile. In some places strata of sandy material are throughout the profile as well as on the surface. In places faint mottles of gray are in the subsoil and substratum.

Small areas of the well-drained Gardiner and of the moderately well drained Nestucca soils are included with this soil.

Natural drainage is good, runoff is slow, and permeability is moderate. The available water-holding capacity is high; root penetration is very deep. The hazard of erosion is slight. The soil is medium in organic matter, high in fertility, and strongly acid. It is among soils that are lowest in acidity in the survey area.

This soil is used mostly for pasture and hay. Most areas have been cleared of timber, and the stumps and roots have been removed. In areas of this soil planted

to crops, fertilizer and supplemental irrigation are needed to improve yields.

Most of the dairy farms on this soil are irrigated through sprinklers in summer to supplement the soil moisture. (Capability unit I-1; woodland suitability group 1.)

**Nehalem silt loam, overwashed, 3 to 7 percent slopes (NeB).**—This soil differs from Nehalem silt loam, 0 to 3 percent slopes, in that it formed in more recent alluvium and has a very weak structure. Fresh deposits of silt and sand ranging from 1 to 10 inches in thickness cover the area. This soil generally occurs in sharp bends of streams and is flooded during times of high water. Floods scour the soil in many places and leave brush and logging debris on the surface. This soil has an area of only 173 acres and is used exclusively for pasture and hay.

Leveling and removal of debris are necessary before new pastures can be seeded. Establishing new seedlings on fresh alluvium is a problem because the fresh material is droughty. This soil needs a vegetative cover during the winter months to protect it from the scouring action of floods. Weeds are a problem because the seeds are carried to this soil by floods. Some areas of this soil in crops are irrigated through sprinklers. (Capability unit IVe-2; woodland suitability group 17.)

## Neskowin Series

The Neskowin series consists of well-drained, dark-colored, strongly acid soils that have formed in residuum that weathered from igneous rocks. The Neskowin soils occur on moderately steep to very steep uplands near Oretown and Neskowin, and they are associated with the Hembre and Winema soils. The parent material resists weathering; so only shallow to moderately deep soils have formed. The original vegetation probably was grasses and ferns. Sitka spruce and red alder occur in isolated areas, but the trees are stunted by wind blast from the ocean.

The surface soil is very dark brown to almost black, friable, and granular. The subsoil is dark brown, friable, and subangular blocky. Fragments of the parent rock are throughout the profile, and they are most numerous in the lower subsoil. The soils are underlain at a depth of 14 to 30 inches by fractured igneous rock. The dark color of these soils is attributed chiefly to the ferns and grasses under which the soils have formed.

The Neskowin soils are used chiefly for natural brushy pasture. Some forage crops are grown on the gentle slopes with the help of fertilizer.

**Neskowin silty clay loam, 20 to 40 percent slopes (NkF).**—This soil is the most extensive of the Neskowin series and occupies the windward side of steep uplands adjacent to the ocean.

Representative profile observed in an isolated area of spruce with an understory of ferns and grasses:

### Surface layer—

0 to 12 inches, very dark brown, friable (dark-brown and slightly hard, dry) silty clay loam; granular structure; sticky and plastic when wet; few pebbles and small concretions of iron.

### Subsoil—

12 to 17 inches, dark reddish-brown, friable silty clay loam; subangular blocky structure; sticky and plastic when wet; few small stones.

17 to 27 inches, dark-brown, friable silty clay loam; subangular blocky structure; sticky and very plastic when wet; approximately 30 percent of layer is small stones.

### Substratum—

27 inches +, slightly weathered igneous rock; fractured.

The main variation is that the parent rock is from 14 to 30 inches below the surface.

Included with this soil are numerous stringers of the Winema soils at the bases of slopes, outcrops of bare rock in places, and very shallow soil in small areas.

Natural drainage is good, runoff is rapid, and permeability is moderately slow. The available water-holding capacity is moderate; root penetration is moderately deep. The erosion hazard is moderate. The soil is very high in organic matter, moderately low in fertility, and strongly acid. A few small concretions of iron are in the surface layer. Nearly all of this soil is used for natural brushy pasture. (Capability unit VIe-3; woodland suitability group 14.)

**Neskowin silty clay loam, 40 to 60 percent slopes (NkG).**—This soil differs from Neskowin silty clay loam, 20 to 40 percent slopes, in having a shallower profile on south and southwest slopes. In addition it contains a high percentage of stones.

Neskowin silty clay loam, 40 to 60 percent slopes, occupies the very steep mountain slopes adjacent to the ocean. Runoff is very rapid and the erosion hazard is severe.

Most of this soil is used for native brushy pasture, mainly for sheep. Most areas are covered by a thin stand of stunted Sitka spruce and red alder. (Capability unit VIIe-3; woodland suitability group 15.)

**Neskowin silty clay loam, 12 to 20 percent slopes (NkD).**—This soil occupies the saddles between ridges and the broad ridgetops. It contains fewer stones and is deeper than the other Neskowin soils. It generally averages about 30 inches to the parent rock. Runoff is medium, and the hazard of erosion is moderate.

Most of this soil is used for pasture, but some on the gentler slopes is used for hay. Areas in crops need fertilizer. (Capability unit IVe-1; woodland suitability group 13.)

## Nestucca Series

The Nestucca series consists of deep, imperfectly drained soils on nearly level bottom lands having shallow swales and depressions. On broad bottoms of large streams, the Nestucca soils occupy positions farthest from the streams; in the narrow bottoms, they occupy the entire bottom land. Nestucca soils formed in the recent medium- and fine-textured alluvium that washed from mixed sedimentary and igneous rocks. The original vegetation was a mixture of trees and shrubs and some water-tolerant plants.

The surface layer is dark brown, very friable, and granular. The subsoil is dark grayish brown, with coarse stains of reddish brown, and is firm and subangular blocky.

Where the Nestucca soils grade to the Nehalem soils, the subsoil contains fewer mottles; where Nestucca soils grade to the Brenner soils, the mottles are closer to the surface.

The Nestucca soils are used for pasture and forage crops.

**Nestucca silt loam (Ns).**—This soil has slopes of 0 to 3 percent, and it occupies flood plains adjacent to alluvial terraces.

Representative profile observed in a grass pasture:

**Surface layer—**

0 to 14 inches, dark-brown, friable (brown and soft, dry) silt loam; granular structure.

**Subsoil—**

14 to 41 inches, dark grayish-brown, firm silty clay loam mottled with coarse stains of reddish brown; subangular blocky structure; sticky and plastic when wet.

**Substratum—**

41 to 60 inches +, dark-gray, firm silty clay mottled with many coarse stains of dark reddish brown; massive; very sticky and plastic when wet.

The chief variation is in the degree of mottling and the amount of fine-textured particles in the subsoil. The surface soil in some instances contains faint stains of reddish brown. As the soil grades toward the restricted drainage typical of the Brenner soils, the subsoil color becomes grayer, and the texture becomes finer. The soil is intermediate between the well-drained soils and the imperfectly drained soils. Profile colors indicate the degree of natural drainage.

In transitional areas, this soil may include small areas of the Brenner, Nehalem, or Hebo soils. Small patches of Brallier peat are included in some places.

This soil is moderately well drained. The subsoil is moderately permeable. Runoff is very slow, and the hazard of erosion is slight. The available water-holding capacity is high; root penetration is deep. The soil is medium in organic matter, moderately high in fertility, and strongly acid.

Open ditches and tile have been used to improve the drainage in many areas of this soil. However, most of the soil still needs drainage. After drainage has been improved, fertilizers are needed to grow crops successfully. Some areas are irrigated through use of sprinklers. (Capability unit IIw-2; woodland suitability group 5.)

## Netarts Series

The Netarts series consists of deep, excessively drained soils on the older, moderately steep to strongly sloping, stabilized dunes near the coast. Netarts soils make up most of the acreage of the older stabilized dunes. Large acreages of these soils are near Nehalem, Manzanita, Netarts, Oceanside, and Sand Lake, in association with the Yaquina soils. The native vegetation consists of shore pine and an understory of huckleberry, manzanita, kin-nikinnik, and rhododendron. A few stands of Douglas-fir and hemlock are on the older dunes.

The surface soil is black to grayish brown, and loose to very friable. The subsoil is dark brown to reddish brown. It has very firm nodules consisting of iron-cemented sand grains and is underlain by yellowish-brown and grayish-brown, very friable fine sand.

The Netarts soils have no agricultural value but are well suited to recreational uses. A minor use has been made of the timber, and some use has been made of the shrubs by those who pick and sell the foliage.

**Netarts fine sandy loam, 7 to 30 percent slopes (NtF).**—This soil occupies old sand dunes near the ocean.

Representative profile observed under native vegetation:

1½ inches to 0, litter of partly decomposed pine needles, leaves, and roots.

**Surface layer—**

0 to 3 inches, black, very friable fine sandy loam; massive; extremely acid.

3 to 7 inches, dark grayish-brown and light brownish-gray, very friable loamy fine sand; massive; very strongly acid.

7 to 13 inches, grayish-brown and light yellowish-brown loamy fine sand; few, firm, dark-brown, iron-cemented nodules; strongly acid.

**Subsoil—**

13 to 35 inches, reddish-brown to dark-brown, very friable to firm, fine sand; numerous, large, very firm nodules of iron-cemented sand.

35 to 52 inches, yellowish-brown and brownish-gray, very friable fine sand; few weakly cemented nodules.

**Substratum—**

52 inches +, pale-yellow and dark grayish-brown, very friable fine sand.

The chief variation is in degree of profile development. The development of a profile in Netarts soils is related to the age of stabilization of the dunes and to the type of vegetation that followed stabilization. The soils in the Netarts-Oceanside area and those that adjoin Sand Lake have a strongly developed profile, which is typical of the Netarts series. The soils near the Nehalem-Manzanita vicinity have only a weakly developed profile but also have the definite gray color of the leached surface soil and the brown to reddish-brown iron cementation in the subsoil.

Included with this soil are small, irregular patches of active sand dunes or of Brallier peat. Also included are areas of Yaquina soils too small to be mapped separately.

Natural drainage is excessive, runoff is very slow, and permeability is very rapid. The available water-holding capacity is very low; root penetration is deep. The hazard of wind erosion is severe. The soil is low in organic matter and fertility and is very strongly acid.

Use of this soil is limited to the growth and harvest of the natural cover—shore pine and spruce for wood, and shrubs for foliage. (Capability unit VIIe-4; woodland suitability group 16.)

## Quillayute Series

The Quillayute series consists of moderately deep to very deep, well-drained, very strongly acid soils on stream terraces in the central part of the Tillamook survey area. Most of the Quillayute soils are nearly level, but some are gently undulating and strongly sloping. The Quillayute soils are associated with the Meda, Knappa, Ginger, and Hebo soils. They formed in old alluvium that originated in mixed igneous and sedimentary rocks. The natural vegetation probably was brackenfern, brush, and some grass. Spruce and hemlock are in a few scattered places.

The surface soil is black, friable, and granular. The subsoil is dark grayish brown to dark yellowish brown, friable, and subangular blocky. At a depth of 26 to 120 inches, the Quillayute soils are underlain by stratified layers of compacted gravel and coarse sand. As a rule, the layer of gravel is nearer to 120 inches than to 26 inches from the surface. The Quillayute soils occur on two terrace levels. Those on the lower terrace have a

shallower profile and have the layer of underlying gravel nearer the surface.

The Quillayute soils are used for improved pasture and forage crops.

**Quillayute silt loam, 0 to 7 percent slopes (QcB).—**

This soil occupies nearly level to gently sloping terrace positions between the upland and flood plain and is adjacent mainly to the soils of the Ginger and Hebo series.

Representative profile observed in a pasture of native and tame grasses:

**Surface layer—**

0 to 21 inches, black, friable (very dark gray and soft, dry) silt loam; granular structure.

**Subsoil—**

21 to 30 inches, very dark grayish-brown, friable, light silty clay loam or silt loam; granular structure; slightly sticky and slightly plastic when wet.

30 to 48 inches, dark yellowish-brown, silty clay loam or silt loam; subangular blocky structure; sticky and plastic when wet.

48 to 60 inches +, light yellowish-brown, firm silty clay loam or silt loam; subangular blocky structure; sticky and plastic when wet.

The chief variation is in the thickness of the black surface horizon. This horizon is generally shallower in soils that occupy positions on the lower terraces. In places waterworn gravel occurs throughout the profile.

Included with this soil are small depressed areas of the Ginger and Hebo soils and convex areas of the Meda and Knappa soils.

Natural drainage is good, runoff is medium, and permeability is moderate. The available water-holding capacity is high; root penetration is deep. The hazard of erosion is slight. The soil is very high in organic matter, moderately low in fertility, and very strongly acid.

This soil is used mainly for improved pasture and hay. Areas in these crops require fertilizer. The crops respond to sprinkler irrigation. Spruce and hemlock are in a few small areas. (Capability unit IIe-1; woodland suitability group 4.)

**Quillayute silt loam, moderately deep, 0 to 12 percent slopes (QmC).—**This soil occurs in nearly level to sloping and undulating terrace positions in the South Prairie community along the Tillamook River. It is similar to Quillayute silt loam, 0 to 7 percent slopes, but has weak structure and at a depth of 26 to 36 inches is underlain by a layer of coarse sand and gravel. Small areas of this soil also occur on strongly sloping terrace escarpments that join the bottom land. Included with this soil, where the terrace joins the uplands, are small patches of Meda soil.

Natural drainage is good, runoff is medium, and permeability is moderate. The available water-holding capacity is moderate; root penetration is moderately deep. The hazard of erosion is slight. This soil is very high in organic matter, moderately low in fertility, and very strongly acid.

This soil is used principally for improved pasture. Areas in pasture require fertilizer and irrigation. (Capability unit IIIe-1; woodland suitability group 4.)

## Riverwash (Re)

This mapping unit consists of a wide variety of coarse sand, gravel, cobblestone, and other sediment that has

recently been deposited by streams. This material generally occurs in narrow, broken strips on flats and bars near the banks of streams. It is also in the beds of many abandoned cutoffs and meanders.

Riverwash generally has a level to slightly undulating surface and is slightly higher than the normal level of channels in which it occurs. It is subject to frequent flooding, and its boundaries are constantly changing. The depth, area, and layering of the deposits and the size of aggregates in the deposits depend on the source of the sediment, the gradient of the channel, and the size of the stream. Shale sediment first breaks down into small stones or gravel; basalt disintegrates into large boulders and gradually into material the size of stone and gravel. Deposits of riverwash are generally many feet thick over old marine sediment or shale bedrock.

Riverwash of recent deposition is generally bare of vegetation, but older deposits covered by a thin layer of silty material have grasses, willows, and alders growing on them.

The only use of Riverwash is for channel protection and as material used in construction. (Capability unit VIIIc-1; woodland suitability group 18.)

## Rock Land (Ro)

This miscellaneous land type occurs on mountain ridgetops, and it consists of 40 to 70 percent of rock outcrop and very shallow soil. The Tillamook survey area has 49 acres of this land type. About 15 percent of the acreage is covered in stunted Douglas-fir, occasional salal, and red huckleberry. This land type is useful only for wildlife and recreation. (Capability unit VIIIc-1; woodland suitability group 18.)

## Tidal Flats (Tf)

This land type consists of low tideland adjacent to bays and inlets along the coast. It includes the barren, nearly flat areas of mud, periodically covered by tidal water. The lower Tidal flats are covered by water daily; the higher parts may be covered only when tides are unusually high.

Tidal flats consist of mud and raw peat that are little altered and show very little, if any, weathering. Normally, tidal flat material has an excess of soluble salts, and most of the sparse native vegetation growing on it can tolerate the salts. The surface of tidal flats generally is not hard enough to support a man, except in dry summer months and at low tide. Tidal flats have practically no agricultural value. (Capability unit VIIIw-1; woodland suitability group 18.)

## Winema Series

The Winema series consists of dark-colored, well-drained, deep to moderately deep soils on the lower slopes along river valleys and on hills adjacent to the coast. Slopes are gentle to steep, moderately long, and smooth. They have mostly a south or southwest exposure. The Winema soils are associated with the Astoria, Hembre, and Neskowin soils on uplands and with the Quillayute soils on terraces. Large areas of Winema soils are near Bay City, Trask River, Oretown, and



Neskowin. The Winema soils formed from soft gray shale under ferns and grasses. Sitka spruce occurs in small groups scattered over the area of Winema soils.

The surface soil is black, friable, and granular. The subsoil is dark brown to dark yellowish brown, firm, and subangular blocky. In places the black, highly organic surface soil rests directly on yellowish-gray shale.

Winema soils are used principally for improved pasture and forage crops. The steep areas are used primarily for sheep pasture.

**Winema silt loam, 20 to 40 percent slopes (Wef).**—This soil occupies moderately long, smooth, steep windward slopes of uplands adjacent to the ocean.

Representative profile on a south slope in a pasture of grasses and ferns:

**Surface layer—**

0 to 21 inches, black, friable (very dark gray and soft, dry) silt loam; granular; slightly sticky and slightly plastic when wet; contains a large quantity of fibrous and sooty organic matter.

**Subsoil—**

21 to 28 inches, dark-brown, firm silty clay loam; subangular blocky structure; sticky and plastic when wet; few, small, decomposed fragments of shale.

28 to 42 inches, dark yellowish-brown, firm silty clay; subangular blocky structure; sticky and plastic when wet; many decomposed fragments of shale.

**Stratum—**

42 to 60 inches +, variegated brown and yellowish-brown silty clay; massive; mixed with slightly weathered soft shale.

The chief variation is in the depth to weathered shale and in the thickness of the subsoil. In some places weathered shale is 72 to 80 inches below the surface, and in other places it is only 20 to 36 inches from the surface. The thickness of the surface layer generally does not change.

Included with this soil are small areas of the Neskowin, Hembre, and Astoria soils.

Natural drainage is good, runoff is rapid, and permeability of the subsoil is moderate. The available water-holding capacity is high; root penetration is deep. The hazard of erosion is moderate to severe. The soil is very high in organic matter, moderately low in fertility, and very strongly acid.

The mild slopes are used for improved pasture; the steep slopes are in native vegetation and are used for sheep pasture. Some acreage is in Sitka spruce. (Capability unit VIe-3; woodland suitability group 8.)

**Winema silt loam, 3 to 12 percent slopes (WeC).**—This soil is on gently sloping to rolling positions at the bases of slopes along valleys. It is somewhat deeper than Winema silt loam, 20 to 40 percent slopes, but otherwise varies only slightly from it. Runoff is slow to medium, and the hazard of erosion is slight. Included with this soil are small areas of Quillayute soils.

This soil is used almost entirely for improved pasture and hay. Fertilizer is needed for these crops. (Capability unit IIIe-1; woodland suitability group 7.)

**Winema silt loam, 12 to 20 percent slopes (WeD).**—This soil occupies the moderately steep valley slopes. Its profile is similar to that of Winema silt loam, 20 to 40 percent slopes. Runoff is medium, and the hazard of erosion is moderate.

This soil is used almost exclusively for improved pasture; some small acreages are harvested for hay. (Ca-

pability unit IVe-1; woodland suitability group 7.)

**Winema silt loam, moderately deep, 20 to 40 percent slopes (Wmf).**—This soil occurs mainly in the vicinities of Oretown and Neskowin. It is like Winema silt loam, 20 to 40 percent slopes, except that the parent shale is 22 to 34 inches below the surface, and the surface soil is thinner over a thin subsoil horizon. In some places the surface soil rests on weathered shale.

In a typical profile of Winema silt loam, moderately deep, 20 to 40 percent slopes, the surface layer is 12 to 20 inches of black, friable, granular silt loam; the subsoil is 5 to 12 inches of very dark grayish-brown to dark-brown, firm, subangular blocky silty clay loam, underlain by weathered grayish and yellowish shale. Included with this soil are small areas of the Astoria, Hembre, and Neskowin soils.

The available water-holding capacity is moderate, root penetration is moderately deep, and the erosion hazard is moderately severe. The soil is very strongly acid. It is used mainly as native pasture for sheep. Small areas of spruce are scattered over the soil. (Capability unit VIe-3; woodland suitability group 8.)

**Winema silt loam, moderately deep, 12 to 20 percent slopes (WmD).**—This soil is on strongly sloping lower uplands and foothills. The profile is like that of Winema silt loam, moderately deep, 20 to 40 percent slopes. The hazard of erosion is moderate. The soil is used entirely for improved pasture. (Capability unit IVe-1; woodland suitability group 7.)

## Yaquina Series

The Yaquina series consists of nearly level, imperfectly drained soils in low, interdune positions along the coast. The Yaquina soils formed in beach sand and in the sand of old dunes that were leveled by the action of wind and water. They are associated with the Netarts and Brallier soils. The height of the water table fluctuates from 1 to 5 feet. The vegetation consists of shore pine, rhododendron, azalea, spirea, salal, huckleberry, honeysuckle, and scattered spruce.

The surface soil is gray, loose, and single grained. The subsoil is dark grayish-brown to grayish-brown, loose, fine sand. Under native vegetation, the surface layer is a mixture of very dark gray to almost black organic matter and sand,  $\frac{1}{2}$  inch to 1 inch thick. Near Sand Lake the soil is underlain by bluish-gray to gray tidal mud. In some areas the profile has dark-colored, buried horizons of an older soil that are high in organic matter.

Yaquina soils are used chiefly for pasture and forest, but there are several very small acreages that produce good yields of cranberries and blueberries. Yaquina soils are also used for small-acreage suburban homesites.

**Yaquina loamy fine sand, 0 to 3 percent slopes (YaA).**—This soil occurs in depressions between old, stabilized sand dunes.

Representative profile observed under a cover of shore pine, huckleberry, and salal:

$\frac{1}{2}$  inch to 0, very dark gray, very friable, partly decomposed mixture of organic matter and loamy fine sand.

**Surface layer—**

0 to 6 inches, gray, loose loamy fine sand (light gray and loose, dry); single grained.

## Subsoil—

6 to 14 inches, dark grayish-brown, loose fine sand; coarse, distinct stains of reddish brown and yellowish red; single grained; few firm, iron-cemented nodules.

14 to 30 inches, grayish-brown, loose fine sand; few, fine stains of yellowish brown; single grained.

## Substratum—

30 to 42 inches +, variegated brown and gray, loose sand; few, coarse stains of yellowish brown; single grained.

The chief variation is in the thickness of the leached surface layer, which ranges from 2 to 6 inches. In cultivation this horizon is mixed with the organic layer. The subsoil in places has noticeable iron cementation. In the vicinity of Sand Lake, the Yaquina soils contain buried surface horizons high in organic matter, and in places,

the soils are underlain by tidal mud. Included with this soil are small areas of the Netarts soil and very small areas of Brallier peat.

Natural drainage is imperfect, runoff is very slow, and permeability of the subsoil is very rapid. The available water-holding capacity is low; root penetration is moderately deep. The hazard of wind erosion is moderate. The soil is low in organic matter and fertility and is very strongly acid.

This soil is used for homesites and for improved pasture, hay, and timber. Some cranberries and blueberries are grown. Areas of this soil in cultivation require drainage, fertilization, and irrigation. (Capability unit IIIw-3; woodland suitability group 6.)

TABLE 6.—*Genetic relationships and great soil groups of the soil series in the Tillamook survey area*

Soil series	Great soil group	Parent material	Natural drainage	Natural vegetation
Astoria	Sols Bruns Acides	Sedimentary residuum	Good	Coniferous forest.
Brallier	Bog soils	Organic material	Very poor	Marsh.
Brenner	Low-Humic Gley soils	Recent alluvium	Poor	Coniferous forest.
Chitwood	Sols Bruns Acides	Old alluvium	Imperfect	Coniferous forest.
Coquille	Low-Humic Gley soils	Recent alluvium	Very poor	Marsh.
Gardiner	Alluvial soils	Recent alluvium	Good	Coniferous forest.
Gauldy	Alluvial soils	Recent alluvium	Good	Coniferous forest.
Ginger	Ando soils	Old alluvium	Imperfect	Shrubby grassland.
Hebo	Humic Gley soils	Old alluvium	Poor	Forest or grassland.
Hembro	Sols Bruns Acides	Basalt residuum	Good	Coniferous forest.
Knappa	Sols Bruns Acides	Old alluvium	Good	Coniferous forest.
Meda	Alluvial soils	Recent alluvium	Good	Coniferous forest.
Nehalem	Alluvial soils	Recent alluvium	Good	Coniferous forest.
Neskowin	Ando soils	Basalt residuum	Good	Shrubby grassland.
Nestucca	Alluvial soils	Recent alluvium	Imperfect	Coniferous forest.
Netarts	Podzols	Sand	Good	Shrub thicket.
Quillayute	Ando soils	Old alluvium	Good	Shrubby grassland.
Winema	Ando soils	Sedimentary residuum	Good	Shrubby grassland.
Yaquina	Podzols	Sand	Imperfect	Shrub thicket.

## Genesis, Classification, and Morphology of the Soils<sup>5</sup>

This section discusses the formation of soils, their classification into great soil groups, and their physical and chemical properties.

### Factors of Soil Formation

Five factors have determined the formation of soils in the Tillamook survey area. These factors are (1) climate, (2) plant and animal life, (3) parent material, (4) relief, and (5) time.

Except for time, each of these factors is a complex of natural phenomena. Climate is a complex of the quantity of rainfall and its seasonal distribution, cloudiness, temperature, and so on. Moreover, one group of factors influences another. Vegetation is very strongly influenced by climate. Parent material and relief are strongly interrelated. Characteristics of any soil are determined

by and can be explained by these five factors. Table 6 shows the parent material, drainage, vegetation, and great soil group of each soil series in the Tillamook survey area.

### Climate

Climatic data for the Tillamook survey area are given in another section (see table 8, p. 70). In general the Tillamook survey area has high annual rainfall, about half of which falls in winter. Temperatures are fairly uniform throughout the year. Freezing temperatures are rare in the winter. Summers are cool.

Climate influences the formation of soils through its control of (a) natural vegetation, and (b) of water supply and temperature.

Soil temperature in the Tillamook survey area is probably never high. On the other hand, the soil is almost never frozen, and the process of soil formation can proceed in winter. For about 5 months of the year, rainfall is enough to allow frequent to almost continuous leaching. During the relatively dry summers, the soil contains less moisture, but in most years most soils are dried to the wilting point in only the surface 6 inches. Thus, enough water is available the whole year for most processes of soil formation other than leaching.

<sup>5</sup> This section was written by DR. ELLIS G. KNOX, Dept. of Soils, Oregon State University. DR. G. H. SIMONSON, Dept. of Soils, Oregon State University, supplied the tables of laboratory data. CLYDE C. BOWLESBY, Soil Conservation Service, prepared the soil profile descriptions.

Climate within the Tillamook survey area is fairly uniform. Variations large enough to produce significant soil differences are not known. However, there may be subtle differences that produced coniferous forest in some places and shrubby grassland vegetation in others.

### *Vegetation*

Vegetation in the Tillamook survey area has not been studied in detail. Vegetation types have not been defined. Only general relationships are presented here. Four major kinds of natural vegetation may be recognized. They are coniferous forest, shrubby grassland, shrub thicket, and marsh.

The typical coniferous forest is in well-drained areas. Douglas-fir is the dominant forest tree except in areas that have been undisturbed for more than one generation of trees. In undisturbed areas, hemlock may be dominant; western redcedar, Sitka spruce, alder, and bigleaf maple are also present. Red huckleberry, salal, salmonberry, and swordfern are characteristic species in the understory. Coniferous forest on recent alluvium is more variable and may tend to include plants typical of shrubby grassland. In poorly drained areas, Sitka spruce, ash, rushes, sedges, and skunkcabbage tend to exclude the other species generally found in better drained areas of coniferous forest.

Shrubby grassland vegetation in well-drained areas consists of grasses, strawberry, cinquefoil, iris, brackenfern, swordfern, other herbaceous plants, and generally the somewhat dwarfed forms of salal and evergreen huckleberry. Most areas in shrubby grassland vegetation have been cultivated or grazed; so the natural plant composition is less well known than in other areas. Shrubby grassland vegetation in wet areas has rushes and skunkcabbage but no shrubs.

The presence of shrubby grassland in an area that is dominantly coniferous forest has not been explained. On uplands, shrubby grassland tends to be restricted to areas within a limited distance from the coast, and it commonly occurs on headlands extending into the ocean. However, extensive areas also occur on uplands and on terraces that are as much as 5 miles from the coast. Salt spray, wind, fog, and fire have been offered as explanations for the presence of shrubby grassland. More than one simple explanation is probably involved.

Shrub thicket consists of very dense stands of shore pine, evergreen huckleberry, salal, manzanita, and rhododendron. This type of vegetation is restricted to beach and dune areas that have sandy parent material.

Marsh vegetation consists of rushes, bulrushes, sedges, grasses, and other grasslike plants. It occurs in tidal areas that are subject to inundation by fresh, brackish, or salt water.

Vegetation influences soil formation chiefly by controlling (1) the kind, amount, and depth distribution of organic material added to the soil, (2) the nutrient circulation, and (3) the degree of protection to the soil surface. Organic matter influences the production of organic solutions, which may take part in the leaching and rock decomposition processes. Nutrient circulation is the reutilization by plants of nutrients released in decay of organic residue. It is a common phenomenon but is particularly important where the soils are subject

to a high leaching potential. Loss of nutrients from the root zone through leaching is reduced by interception of the nutrients by roots.

Marsh vegetation has not been a strong influence on soil formation. Soils on tidal areas are very weakly developed, and the influence of a high water table is strong.

The influence of shrub thicket vegetation is difficult to evaluate. The sandy parent material, to which it is restricted, may determine the character of the soils as much as, or more than, the vegetation. In any event, the circulation of nutrients has not been very effective. Organic matter has accumulated mostly on the soil surface.

Coniferous forests and shrubby grasslands have furnished a great amount of organic matter that has accumulated in the upper foot or more of soil. Circulation of nutrients evidently has maintained the meager supply of nutrients against a strong leaching potentiality.

Animals, such as earthworms, insects, and moles, that live in the soil have a retarding influence on soil development because they remix soil material. Microorganisms are very important in the decomposition of plant and animal materials into soil organic matter and in transformation of nutrient elements from one chemical form to another.

### *Parent material*

Soils of the Tillamook survey area have formed through the alteration of (1) residuum on hills, (2) alluvium on terraces, fans, flood plains, and tidal flats, (3) sand on beaches and in dunes, and (4) organic material. The size of particles, hardness of rock fragments, mineralogy, and thickness of the parent material are characteristics that have influenced the nature of the soils.

Parent material is not completely altered in the process of soil formation. As a result, the soils have many of the original characteristics of the parent material. For example, the soils on flood plains inherited their texture directly from the parent alluvium. The kind and extent of alteration of parent materials are limited by the original characteristics of the material. For example, the Hembre soils are redder than the Astoria soils because the parent material of the Hembre soils has more capacity for the production of reddish iron oxides than that of the Astoria soils.

Some types of parent material determine the course and direction of their own alteration. For example, the very rapid permeability and low water-holding capacity of dune sand and beach sand determine the kind of vegetation that will grow and the behavior of water in the soil. In this case permeability and water-holding capacity have influenced the trend of soil formation.

Residuum (or colluvium) forms through the weathering of bedrock on hill slopes. It is no longer absolutely in place but has moved downslope. It tends to be silty or loamy, and it varies in amount of rock fragments and in thickness.

Residuum that weathered from sedimentary rock—siltstone or mudstone—tends to be higher in clay and thicker over bedrock, and it contains fewer and softer stones than the residuum from basalt. Both types of residuum contain a range in minerals and, therefore, have a range in potential alteration in the process of soil

formation. Both kinds of residuum are basic in the lithologic sense, that is, they are low in silica and high in iron, magnesium, and calcium. There is little or no quartz in basalt residuum and probably less than 30 percent in sedimentary residuum.

Alluvium that washed from both kinds of rocks has been transported by water and deposited in a new location. In moving from one place to another, it was mixed enough so that the original characteristics were no longer distinct. The alluvium is said to have a mixed mineralogy.

Old alluvium forms river terraces. Young alluvium forms stream flood plains that merge into tidal flats, and it forms alluvial fans where small tributaries flow into valley streams. The older alluvium is silty and, in places, may contain some gravel. The younger alluvium in broad flood plains and tidal flats is silty or sandy. On narrow upstream flood plains, the younger alluvium is mainly hard, washed gravel. On fans, it is not well sorted but is generally loam and contains varying amounts of rock fragments.

Dune sand and beach sand are from the ocean. They probably weathered largely from basalt and sedimentary rocks, but the sorting and wearing action of the ocean has been severe. There is a narrow range in particle size, and a concentration of quartz.

The organic material has accumulated in place from rooted plants growing in wet areas.

### **Relief**

Relief is strongly related to the origin of parent material. Thus, soils that formed in residuum are on the slopes of hills, those from alluvium are on the nearly level surfaces of valleys, and those from dune sand and beach sand are on short slopes in an irregular pattern of ridges and troughs.

Slope is an important part of relief. It strongly influences the disposition of precipitation and the susceptibility of a soil to water erosion or downslope movement.

The amount of runoff increases, and the penetration of water decreases as the slope of a soil increases. All sloping soils in the Tillamook survey area readily take in water. Precipitation generally comes as steady, gentle rains. Rapid runoff is rare. No soil in the survey area is droughty simply because of steepness of slope.

In some places water concentrates on the soil or is retained in the soil, so that the soil is wet for a significant part of the year. Several degrees of wetness are recognized in classifying natural drainage. Soils that are less than well drained have formed on terraces, flood plains, and tidal flats, and in the troughs of dune areas and beach sand. In general, these soils are wet because of their position. The water table is near the soil surface. However, the Hebo soils are slowly permeable, and the retention of water by the soils themselves may contribute to their wetness.

Soils in the Tillamook survey area with their cover of natural vegetation are very resistant to water erosion, even on the steepest slopes. Mass movement of soil downslope, however, still occurs as it has in the past.

### **Time**

The formation of soil from parent material takes time. Factors other than time being equal, young soils have more weakly expressed horizons than old soils.

Soils that formed in residuum on hills and those that formed from old alluvium on terraces are old enough to be moderately well developed. Soils that formed from the younger alluvium on flood plains and tidal flats are weakly developed. They are very little different from the material as it was originally deposited. Soils that formed in alluvium on fans are more variable in their development, but they are the most weakly developed.

Soils that formed in dune and beach sands may be fully as old as the soils that formed in old alluvium, or they may be younger. They are less well developed, but the mineralogy and coarse texture of the sand restrict the rate and amount of development.

The slumping of soils on hills destroys areas of residual soils through burial and by shattering and mixing of material in the slumped block. New surfaces are exposed to weathering. As a result, there are local differences in age of these soils and in the degree of soil development.

## **Genetic Processes and Soil Characteristics**

Soils in the Tillamook survey area have formed from parent material through the action of many physical, chemical, and biological processes. The same general processes have acted on the parent material of all soils of the Tillamook Area and on the parent material of all the soils of the world. Differences in soils are the result of differences in parent material, and in differences in the relative importance of the various processes controlled by the other factors of soil formation.

Most of our information about the genetic processes is inferred from our knowledge of the results of these processes. The genetic processes produced the following important features in soils of the Tillamook survey area: (1) A horizon that has an accumulation of organic matter; (2) very low base saturation; (3) B horizon; (4) high porosity, low bulk density, and smeariness; (5) thick, dark-colored horizon; (6) podzol sequence of horizons; (7) mottles and gray colors.

Each of these features is discussed in the paragraphs that follow. Table 7 shows the laboratory analyses of the Astoria, Hebo, Nehalem, Quillayute, and Winema soils.

### **The A horizon**

Almost all soils of the Tillamook survey area have an A horizon with a pronounced accumulation of organic matter and with strong, stable structure. The amount of organic matter in the A horizon is a balance between additions, mainly from plants, and losses, mainly from oxidation, caused by microbial decomposition and the return of oxidation products to the atmosphere.

In the Sols Bruns Acides and Ando soils, the balance between additions and losses favors a high level of organic matter. (See table 7 for the laboratory analyses of Astoria, Quillayute, and Winema soils.) Soils that formed in recent alluvium have lower levels of organic matter because of the adverse effect of floods on natural vegetation and the continuing additions of alluvium dur-



ing floods. The amount of organic matter in Alluvial soils decreases less rapidly with depth than it does in the other soils. (See laboratory analysis of the Nehalem soils in table 7.) Organic matter in the soils formed in dune sand and beach sand will be discussed in a later paragraph.

Vegetation grows vigorously because of high rainfall, and it adds large amounts of organic matter to soils. However, decomposition is active most of the year because moisture conditions are favorable. Low summer temperatures, together with low base saturation, probably reduce the rate of decomposition, so that high levels of organic matter can be maintained in soils.

### **Base saturation**

The well-drained soils, except those that formed in recent alluvium, are very low in base saturation (table 7). The Astoria, Quillayute, and Winema soils are extremely heavily leached because of high precipitation and the permeability of the soils. Nutrient circulation by plants has maintained the cations of calcium, potassium, and magnesium only at low levels. Wet soils, such as those of the Hebo series (table 7), are higher in base saturation than the well-drained soils. It is not known if the base saturation of the Ginger and Chitwood soils is more like that of the Hebo or more like that of the Astoria, Quillayute, and Winema soils. The higher base saturation of the wetter soils is probably caused by the movement of bases in ground water into these soils from the surrounding well-drained soils and to slower and less frequent drainage of water through these soils. Soils that formed in recent alluvium have higher base saturation (see data for the Nehalem soils in table 7) because of the continuing additions of fresh alluvium in floods.

### **The B horizon**

The Astoria, Chitwood, Hembre, Knappa, and Hebo soils have a B horizon with clearly expressed soil structure. The B horizon contains more clay than the overlying A horizon. In addition, the ped and pore surfaces are smooth, as though they were coated with clay. However, except for the Hebo soils, microscopic studies show that clay on these surfaces is not oriented as it would be if it had moved in soil water from the A horizon to the B horizon. The higher content of clay in the B horizon than that in the A horizon must be the result of the greater formation of clay in the B horizon or the greater destruction of clay in the A horizon. Very young soils commonly do not show evidence of clay movement from one horizon to another horizon. One explanation for the lack of such evidence in the Astoria, Chitwood, Hembre, and Knappa soils is that these soils and the surfaces on which they have formed are too young. Alternatively, these soils may have no tendency for movement of clay in the soil water.

The Hebo series has a "tough" B horizon that is high in clay. Superficially, this suggests strong textural development. However, the increase in clay from the A to the B horizon is not large or abrupt, and it is possible that the clay has been inherited from the parent material rather than having been formed in the soil as a result of soil development.

### **Porosity, bulk density, and smeariness**

High porosity, low bulk density (see table 7), and smeariness are characteristic of the Sols Bruns Acides and Ando soils and, to a lesser extent, of the well-drained Alluvial soils. Smeariness is observed during manipulation of moist material. It is the tendency of soils to shear suddenly rather than gradually when subjected to deformation. In addition, these soils tend to be softer when dry, more friable when moist, and less sticky and less plastic when wet than soils in other parts of the State that contain similar amounts of clay.

High porosity, low bulk density, and smeariness occur together and seem to be restricted in Oregon to soils in areas of high rainfall. High rainfall and abundant soil moisture must figure some way in the origin of these characteristics. High amounts of organic matter are not the source of these characteristics, because B horizons that are not particularly high in organic matter, as well as A horizons, have these characteristics. The high content of plant roots and the rapidity of their growth and the great activity of burrowing animals may contribute somewhat to porosity. The fundamental explanation of these characteristics, however, probably involves the mineralogy of the clay. A current working hypothesis is that allophane clay is responsible for the set of characteristics under consideration. The origin of allophane may depend on the nature of the parent material, the deficiency of metallic cations as indicated by low base saturation, the abundance of moisture, or on some combination of these conditions.

### **Thick, dark-colored horizon**

The Ginger, Neskowin, Quillayute, and Winema soils, all of which are classified as Ando soils, have very thick, almost black A horizons. The A horizon of these soils has the high porosity, low bulk density, and smeariness discussed previously. This horizon is high in organic matter and is believed to be rich in allophane. (See laboratory data for Quillayute and Winema soils in table 7.)

The difference between the A horizon of these Ando soils and the less extreme A horizon of the Sols Bruns Acides is related to and perhaps caused by differences in natural vegetation. Reasons for the difference, other than that of vegetation, have not been suggested.

In some places outside of the Tillamook survey area, the vegetation on Ando soils is almost exclusively brackenfern, and this plant has been considered as having been responsible for the development of the A horizon in Ando soils. This consideration is strengthened by the fact that the brackenfern root has a black exterior, which resists decomposition. However, in the Tillamook survey area, brackenfern is not strongly dominant, and in many areas it is almost completely absent. Consequently, it is unlikely to have been responsible for formation of the Ando soils.

The vegetation of the Ando soils, referred to here as shrubby grassland, is not well known because so much of it has been destroyed by cultivation and altered by grazing. The composition of shrubby grassland ranges from almost completely dominant grass and grasslike plants to almost completely dominant dwarfed, close-growing shrubs. Reasons for the presence of shrubby

TABLE 7.—*Soil characterization data for five*  
[Analyses by the Agricultural Experiment Station, Oregon State]

Soil type, profile number, and location	Depth from surface	Particle-size distribution in millimeters											Textural class
		Horizon	Very coarse sand (2-1)	Coarse sand (1-0.5)	Medium sand (0.5-0.25)	Fine sand (0.25-0.1)	Very fine sand (0.1-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Total sand	Particles		
											0.02-0.002	0.02-0.05	
Astoria silt loam: S58 Oreg 29-2-(2-8); SW¼NE¼ sec. 23, T. 1 S., R. 8 W.	Inches 0-6 6-14 14-25 25-35 35-50 50-66 66-74	A11 A12 B21 B22 B3 C Dr	Percent ----- ----- ----- ----- ----- ----- -----	Percent 3.1 4.5 5.0 6.0 2.3 3.9 8.7	Percent ----- ----- ----- ----- ----- ----- -----	Percent 9.2 9.2 11.5 12.8 7.9 5.1 22.0	Percent ----- ----- ----- ----- ----- ----- -----	Percent 49.1 50.6 45.6 43.7 41.1 37.2 45.5	Percent 38.5 35.2 37.7 37.3 48.6 53.7 23.6	Percent 12.4 14.2 16.7 19.0 10.3 9.1 31.9	Percent 41.1 41.9 37.5 36.8 37.1 35.1 32.8	Percent 8.0 8.7 8.1 6.9 4.0 2.1 12.7	Silty clay loam. Silty clay loam. Silty clay loam. Silty clay loam. Clay----- Loam-----
Astoria silt loam: S56 Oreg 29-21-(2-8); SE¼NW¼ sec. 24, T. 1 S., R. 8 W.	0-9 9-19 19-28 28-45 45-50 50-68 68-77	A11 A12 B1 B2 B3 C+Dr Dr	----- ----- ----- ----- ----- ----- -----	5.3 3.8 4.6 4.7 9.1 8.0 5.0	----- ----- ----- ----- ----- ----- -----	7.4 7.4 7.7 8.1 11.4 12.3 16.0	----- ----- ----- ----- ----- ----- -----	55.3 58.0 52.7 44.8 41.7 44.5 45.9	31.9 30.6 34.6 42.3 37.5 35.0 33.1	12.7 11.2 12.3 12.9 20.5 20.3 21.0	41.2 43.0 38.2 32.5 32.7 38.1 40.8	14.1 15.0 14.5 12.3 9.0 6.4 5.1	Silty clay loam. Silty clay loam. Silty clay loam. Silty clay loam. Silty clay loam.
Hebo silty clay loam: S58 Oreg 29-3-(1-6); NE¼ NE¼ sec. 14, T. 4 S., R. 10 W.	0-4 4-9 9-19 19-29 29-38 38+	Apg A3g BG1 BG2 BG3 C	----- ----- ----- ----- ----- -----	.6 .7 .3 1.7 2.5 3.0	----- ----- ----- ----- ----- -----	3.2 2.9 2.6 4.3 5.5 6.1	----- ----- ----- ----- ----- -----	50.7 50.4 49.2 39.3 36.4 30.2	45.2 45.8 47.6 54.5 55.3 60.4	3.8 3.6 2.9 6.0 8.0 9.1	39.9 39.6 34.6 28.3 26.4 22.1	10.8 10.8 14.6 11.0 10.0 8.1	Silty clay--- Silty clay--- Silty clay--- Clay----- Clay----- Clay-----
Hebo silty clay loam: S56 Oreg 29-4-(1-6); SE¼ NE¼ sec. 33, T. 1 S., R. 9 W.	0-4 4-10 10-18 18-28 28-35 35-42	Alg A3g BG1 BG2 BG3 C	----- ----- ----- ----- ----- -----	.7 1.3 .5 1.7 7.9	----- ----- ----- ----- ----- -----	4.8 4.5 3.3 7.0 27.0	----- ----- ----- ----- ----- -----	36.4 34.3 26.8 35.9 38.1	58.1 59.9 69.4 55.4 27.0	5.5 5.8 3.8 8.7 34.9	22.6 21.0 15.5 24.9 24.3	13.4 13.3 11.3 11.0 13.8	Clay----- Clay----- Clay----- Clay----- Clay----- Clay loam---
Nehalem silt loam: S58 Oreg 29-4; NW¼SW¼ sec. 5, T. 2 S., R. 9 W. Naval Air Base fertility plots.	0-9 9-17 17-36 36-54	Alp A12 C1 C3	.1 .0 .1 .0	.1 .1 .1 .1	.2 .2 .1 .1	.9 .9 .8 1.2	4.4 3.5 5.7 7.9	56.7 56.8 58.5 58.9	37.6 38.5 34.7 31.8	5.7 4.7 6.8 9.3	47.4 49.1 45.3 44.1	9.3 7.7 13.2 14.8	Silty clay loam. Silty clay loam. Silty clay loam. Silty clay loam.
Quillayute silt loam: S58 Oreg 29-1-(1-6); sec. 42, T. 1 S., R. 9 W., county fairground.	0-9 9-24 24-35 35-46 46-58 58-70	A11 A12 B1 B21 B22 B23-1	----- ----- ----- ----- ----- -----	1.7 1.7 1.5 2.1 2.5 2.1	----- ----- ----- ----- ----- -----	8.0 8.1 9.2 10.9 10.2 10.8	----- ----- ----- ----- ----- -----	50.1 52.8 56.5 54.1 49.7 52.6	40.1 37.5 32.8 34.8 36.6 34.4	9.7 9.8 10.7 13.0 12.7 12.9	36.5 39.3 41.4 38.9 37.8 39.9	13.6 13.5 15.1 15.2 11.9 12.7	Silty clay--- Silty clay loam. Silty clay loam. Silty clay loam. Clay loam--- Silty clay loam.

*soils in the Tillamook survey area, Oregon*

University. Leaders in columns indicate data not available]

pH (soil-water suspension)	Organic matter				Free iron (Fe <sub>2</sub> O <sub>3</sub> )	Bulk density	Moisture held at—				Total cation exchange capacity (NH <sub>4</sub> OAc)	Extractible cations (milli-equivalent per 100 grams of soil)				Base saturation (ammonium acetate exchange)	Calcium-magnesium ratio
	Organic matter (OC/0.58)	Organic carbon	Nitrogen	Carbon-nitrogen ratio			Tension of 1/10 atmosphere	Tension of 1/2 atmosphere	Tension of 15 atmospheres	Tension of 1 atmosphere		Calcium	Magnesium	Sodium	Potassium		
4.8	Percent 13.0	Percent 7.5	Percent 0.46	16	Percent	Gm./cc.	Percent	Percent	Percent	Percent	Percent	0.35	1.00	0.36	0.94	Percent 5	0.35
4.9	9.2	5.3	.30	18	-----	0.60	82	72	29	58	41.1	.08	.48	.30	.36	3	.17
5.2	2.5	1.4	.11	13	-----	.87	61	57	28	43	37.8	.07	.34	.30	.20	2	.21
4.9	1.4	.8	.07	12	-----	-----	-----	-----	-----	-----	38.8	.36	.52	.47	.22	4	.69
4.8	1.0	.6	.05	12	-----	-----	-----	-----	-----	-----	41.2	.09	.96	.40	.23	4	.09
4.7	.5	.3	.04	7	-----	-----	-----	-----	-----	-----	39.9	.02	.87	.23	.30	4	.02
4.8	.3	.2	.03	6	-----	-----	-----	-----	-----	-----	45.9	.02	.86	.18	.26	3	.02
4.8	12.3	7.1	.40	18	-----	-----	-----	-----	-----	-----	44.6	.58	.75	.46	.78	6	.77
5.0	8.1	4.7	.33	14	-----	-----	-----	-----	-----	-----	33.8	.24	.34	.57	.24	4	.71
5.0	-----	-----	.11	-----	-----	-----	-----	-----	-----	-----	26.4	.20	.30	.40	.20	4	.67
5.2	.6	.3	.06	6	-----	-----	-----	-----	-----	-----	26.0	.39	.80	.45	.15	7	.05
5.0	.5	.3	.05	6	-----	-----	-----	-----	-----	-----	30.7	.14	.98	.44	.15	6	.01
4.9	.3	.2	.04	4	-----	-----	-----	-----	-----	-----	36.7	.08	.90	.30	.17	4	.09
4.9	12.6	7.3	.62	12	-----	-----	-----	-----	-----	-----	34.5	4.0	2.7	.44	.40	22	1.48
4.9	11.6	6.7	.51	13	-----	-----	-----	-----	-----	-----	32.2	4.0	2.9	.46	.32	24	1.38
5.2	2.0	1.2	.10	12	-----	-----	-----	-----	-----	-----	19.3	4.0	3.4	.40	.14	41	1.18
5.2	1.6	.9	.07	13	-----	-----	-----	-----	-----	-----	23.6	4.4	3.6	.52	.17	37	1.22
5.2	1.4	.8	.06	14	-----	-----	-----	-----	-----	-----	38.0	4.4	3.4	.38	.16	22	1.29
5.0	.8	.5	.05	9	-----	-----	-----	-----	-----	-----	29.9	4.7	4.0	.38	.20	31	1.18
4.7	10.7	6.2	.67	9	-----	-----	-----	-----	-----	-----	38.6	.40	.89	.46	.34	6	.55
4.7	6.0	3.5	.44	8	-----	-----	-----	-----	-----	-----	36.2	.58	1.10	.42	.24	6	.53
4.6	1.2	.7	.09	8	-----	-----	-----	-----	-----	-----	36.0	-----	3.82	.50	.21	-----	-----
4.6	.8	.5	.05	9	-----	-----	-----	-----	-----	-----	39.9	4.98	6.10	.52	.24	30	.82
4.9	.8	.5	.05	9	-----	-----	-----	-----	-----	-----	41.0	7.40	8.20	.57	.22	40	.90
5.3	.4	.2	.04	6	-----	-----	-----	-----	-----	-----	48.9	16.80	13.28	.70	.14	63	1.26
7.8	8.3	4.77	.40	12	5.2	-----	-----	-----	-----	-----	53.7	25.4	8.7	.33	.55	65	2.9
8.0	3.7	2.23	.20	11	6.3	-----	-----	-----	-----	-----	50.6	27.0	9.9	.44	.23	74	2.7
8.0	3.5	2.12	.19	11	4.7	-----	-----	-----	-----	-----	48.7	25.8	9.3	.42	.19	73	2.8
8.3	2.2	1.29	.13	9.9	6.8	-----	-----	-----	-----	-----	50.5	26.3	10.8	.69	.21	75	2.4
5.5	18.7	10.8	.62	18	-----	-----	-----	-----	-----	-----	51.9	1.85	1.18	.31	.29	7	1.57
5.4	15.1	8.8	.43	20	-----	.63	74	62	26	56	43.3	.75	.96	.37	.42	6	.78
5.3	5.2	3.0	.23	13	-----	-----	-----	-----	-----	-----	28.6	.40	.39	.22	.24	4	1.03
5.4	2.2	1.3	.16	8	-----	-----	-----	-----	-----	-----	27.9	.60	.75	.38	.24	7	1.80
5.4	1.9	1.1	.15	7	-----	1.05	53	51	24	49	27.7	.70	.98	.42	.24	8	.71
5.4	1.7	1.0	.14	7	-----	-----	-----	-----	-----	-----	30.3	.60	.94	.46	.21	7	.64

TABLE 7.—*Soil characterization data for five*

Soil type, profile number, and location	Depth from surface	Particle-size distribution in millimeters											Textural class
		Horizon	Very coarse sand (2-1)	Coarse sand (1 0.5)	Medium sand (0.5-0.25)	Fine sand (0.25-0.1)	Very fine sand (0.1-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Total sand	Particles		
											0.02-0.002	0.02-0.05	
Quillayute silt loam: S56 Oreg 29-1-(1-5); SW¼NW¼ sec. 13, T. 1 S., R. 10 W.	<i>Inches</i> 0-9 9-21  21-29 29-38 38-60	A1p A12  B21 B22 B3	<i>Percent</i> ----- ----- ----- ----- -----	2. 1 2. 4  2. 5 2. 6 4. 9	----- ----- ----- ----- -----	6. 9 8. 1  8. 7 9. 4 10. 2	----- ----- ----- ----- -----	43. 2 52. 9  52. 1 55. 3 51. 2	47. 8 36. 7  36. 6 32. 7 33. 6	9. 0 10. 5  11. 2 12. 0 15. 1	28. 3 33. 5  34. 5 34. 6 36. 0	14. 9 19. 4  17. 6 20. 7 15. 2	Silty clay... Silty clay loam. Silty clay loam. Silty clay loam. Silty clay loam.
Winema silt loam: S56 Oreg 29-19-(1-5); NE¼NW¼ sec. 34, T. 1 S., R. 9 W.	0-10 10-21 21-28 28-42 42-60	A11 A12 B1 B2 C	----- ----- ----- ----- -----	2. 2 2. 2 3. 4 1. 4 1. 0	----- ----- ----- ----- -----	18. 3 18. 2 22. 9 14. 1 13. 8	----- ----- ----- ----- -----	37. 3 35. 9 35. 8 35. 4 31. 8	42. 2 43. 7 37. 7 49. 1 53. 3	20. 5 20. 4 26. 3 15. 5 14. 8	25. 1 24. 2 24. 4 24. 3 21. 9	12. 2 11. 7 11. 4 11. 1 9. 9	Clay----- Clay----- Clay loam----- Clay----- Clay-----
Winema silty clay loam: S56 Oreg 29-20-(1-5); NW¼SW¼SE¼ sec. 35, T. 1 S., R. 9 W.	0-9 9-23 23-30 30-41 41-60	A11 A12 B1 B2 C	----- ----- ----- ----- -----	2. 1 1. 6 1. 7 3. 7 4. 6	----- ----- ----- ----- -----	7. 4 7. 1 7. 4 5. 5 5. 9	----- ----- ----- ----- -----	34. 8 34. 2 33. 7 31. 7 36. 4	55. 6 57. 0 56. 9 58. 9 53. 0	9. 5 8. 7 9. 1 9. 2 10. 5	24. 9 24. 7 24. 8 25. 4 31. 1	9. 9 9. 5 8. 9 6. 3 5. 3	Clay----- Clay----- Clay----- Clay----- Clay-----

grassland in an area dominated by forest are discussed in the section "Factors of Soil Formation."

#### Podzol sequence of horizons

The sequence consisting of an organic horizon, a horizon from which humus and iron oxides have been leached, and a horizon in which humus and iron oxides have accumulated is characteristic of the Netarts and Yaquina soils and generally of other Podzols.

These three horizons have formed together through an interrelated set of processes. In the first step, plant litter accumulated on the surface of these soils and was not mixed with the mineral material of the soil. The lack of mixing was caused by the failure of animals that live in the soil to transport the organic material into the mineral material. Soil-inhabiting animals may not have liked the litter produced by the native vegetation. In any event, litter accumulated on the surface. Solutions or suspensions of organic compounds leached from this organic layer into the sandy material below. The leached organic compounds combined with iron oxide, or they created conditions that allowed the iron oxides to be dissolved or be taken into suspension. Movement of soil water carried the organic compounds and the iron oxides downward to the horizon of accumulation.

The sandy parent material of the Netarts and Yaquina soils is more susceptible to the illuviation of iron oxides and humus than any other parent material in the Tillamook survey area. This may be the complete explanation for the difference between Netarts and Yaquina soils (Podzols) and the Ando soils and Sols Bruns Acides. On the other hand, the litter produced by the native vege-

tation on Netarts and Yaquina soils may be a better source of the organic compounds needed for the illuviation of iron oxides than the litter produced by the native vegetation on other soils.

#### Mottles and gray colors

Mottled color patterns and gray colors have been produced in wet soils. The imperfectly drained soils have colors like the well-drained soils with which they are associated. In the lower horizons of these soils, gray colors intermingle with brownish or yellowish colors to form a mottled pattern. In the poorly drained soils, the pattern of mottles has brownish and yellowish colors but is dominated by grayish colors that extend to the soil surface. The very poorly drained soils have grayish colors and practically none of the brownish, yellowish, or reddish colors.

The reduction of ferric iron oxides to ferrous iron compounds in waterlogged soils is responsible for the mottled color patterns and gray colors. Reducing agents, derived from the decomposition of organic matter, are necessary for this chemical reaction. Ferric iron oxides are a shade of yellow or red. Ferrous iron compounds are colorless or, in some cases, green or blue. The ferrous compounds may remain in place, or, because they tend to be soluble, may be moved in the soil water. In some cases, gray portions of a mottled pattern are adjacent to reddish portions. This suggests that the ferrous iron has been moved a short distance ( $\frac{1}{16}$  to  $\frac{1}{2}$  inch) and reoxidized to the ferric form. This kind of mottling is characteristic of soils that are intermittently waterlogged and aerated.



## soils in the Tillamook survey area, Oregon—Continued

pH (soil-water suspen- sion)	Organic matter				Free iron (Fe <sub>2</sub> O <sub>3</sub> )	Bulk density	Moisture held at—				Total cation exchange capacity (NH <sub>4</sub> OAc)	Extractible cations (milli- equivalent per 100 grams of soil)				Base saturation (ammo- nium acetate ex- change)	Calcium-magnesium ratio
	Organic matter (OC/0.58)	Organic carbon	Nitrogen	Carbon-nitrogen ratio			Tension of 1/10 atmosphere	Tension of 1/2 atmosphere	Tension of 15 atmospheres	Tension of 1 atmosphere		Calcium	Magnesium	Sodium	Potassium		
		Percent	Percent	Percent		Percent	Gm./cc.	Percent	Percent								
5.0	20.1	11.6	0.86	14	-----	-----	-----	-----	-----	-----	58.2	0.90	1.32	0.44	0.80	6	0.68
5.0	18.1	10.5	.54	19	-----	-----	-----	-----	-----	-----	49.3	.22	.42	.50	.24	3	.52
5.2	10.1	5.9	.34	17	-----	-----	-----	-----	-----	-----	40.4	.16	.38	.38	.20	3	.42
5.2	6.9	4.0	.26	15	-----	-----	-----	-----	-----	-----	36.9	.15	.38	.36	.18	3	.40
5.2	2.3	1.3	.15	9	-----	-----	-----	-----	-----	-----	30.7	.43	.52	.40	.11	5	.83
4.9	10.2	5.9	.44	13	-----	-----	-----	-----	-----	-----	39.8	2.16	2.38	.42	1.38	16	.91
4.9	7.2	4.2	.32	13	-----	-----	-----	-----	-----	-----	33.1	.90	1.65	.58	1.08	13	.55
4.9	1.5	.9	.11	8	-----	-----	-----	-----	-----	-----	38.6	.60	1.64	.41	.35	8	.37
4.8	1.1	.6	.08	8	-----	-----	-----	-----	-----	-----	36.5	.80	2.40	.37	.34	11	.33
4.8	.7	.4	.05	8	-----	-----	-----	-----	-----	-----	34.8	2.12	3.55	.37	.34	20	.60
5.0	12.1	7.0	.58	12	-----	-----	-----	-----	-----	-----	45.5	2.35	3.00	.36	1.87	17	.79
4.9	7.5	4.4	.40	11	-----	-----	-----	-----	-----	-----	41.7	.41	1.55	.40	1.47	9	.36
5.0	4.4	2.6	.27	9	-----	-----	-----	-----	-----	-----	36.2	.12	.98	.40	.70	6	.12
4.9	.9	.5	.08	7	-----	-----	-----	-----	-----	-----	37.8	.16	1.28	.49	.39	6	.12
4.8	.4	.2	.06	4	-----	-----	-----	-----	-----	-----	40.7	.15	1.71	.30	.40	6	.09

## Laboratory Analyses

This part of the report contains results of mechanical and chemical analyses (table 7) of five soils in the Tillamook survey area. Extractable bases were determined by use of the flame photometer and ammonium acetate. The pH was determined by use of the Beckman glass electrode; the organic carbon, by the Walkley-Black method; and the total nitrogen by the Kjeldahl method. Particle-size distribution was determined by use of the pipette method; bulk density, from undisturbed cores. The reader is referred to the work of Alban and Kellogg (1) for additional information on methods of soil analysis.

In table 7, except for the Nehalem soils, the sum of very coarse sand, coarse sand, and medium sand percentages is listed in the coarse sand column, and the sum of fine sand and very fine sand percentages is listed in the fine sand column.

## Classification of the Soils

Soil classification is intended to help us understand relationships and remember characteristics. The system of soil classification currently used in the United States is outlined in the 1938 U.S. Department of Agriculture Yearbook (3). Changes in 1949 and later have been the result of our increased knowledge of the soils (13). An entirely new system of classification will soon replace the 1938 system.

Beginning at the top, the 1938 classification system has six categories, one below the other. These categories

are order, suborder, great soil group, family, series, and type. Among these, the order, great soil group, series, and type have been used most.

The classes in the highest category of the classification system are the zonal, intrazonal, and azonal orders. Each of these orders is represented by the soils in the Tillamook survey area, but only about 15 percent of the great soil groups are represented. The nineteen soil series in the Tillamook survey area constitute a small fraction of 1 percent of the soil series in the United States. The soil series in the Tillamook survey area are classified into the following orders and great soil groups.

## Soil order and great soil group:

	Soil series
Zonal soils:	
Sols Bruns Acides-----	Astoria Chitwood Hembre Knappa
Ando soils-----	Ginger Neskowin Quillayute Winema
Podzols-----	Netarts Yaquina
Intrazonal soils:	
Humic Gley soils-----	Hebo
Low-Humic Gley soils-----	Brenner Coquille Brallier
Bog soils-----	
Azonal soils:	
Alluvial soils-----	Gardiner Gauldy Meda Nehalem Nestucca

## Zonal soils

Zonal soils have developed through soil-forming processes dominated by climate and vegetation. Ideally, in an area of uniform climate and vegetation, one zonal great soil group is formed on a variety of parent materials and in a variety of topographic positions. In the Tillamook survey area, the great soil groups in the zonal order are Sols Bruns Acides, Ando soils, and Podzols.

### SOLS BRUNS ACIDES

Sols Bruns Acides in this survey area have a dark-colored A horizon, a structural B horizon, and very low base saturation. They are mainly well drained, but some are imperfectly drained. The Sols Bruns Acides in Oregon differ from those in the eastern part of the United States (4) and in Europe by having a thicker and darker A horizon with a higher level of organic matter. In addition, they are lower in bulk density and are smeary.

The Sols Bruns Acides in Oregon are similar to the Humic Latosols or to the Latosolic Brown Forest soils of Hawaii (6). The Hawaiian soils evidently are more strongly weathered.

In the Tillamook survey area, the Sols Bruns Acides have formed under coniferous vegetation in residuum that weathered from basalt and sedimentary rocks, and in old alluvium. Because the coniferous forest is the typical vegetation for the climate in the survey area and because the soils have formed in a variety of parent materials, the Sols Bruns Acides are considered to be zonal soils. The Astoria soils are typical. Laboratory data for the Astoria soils (table 7) show that they are low in base saturation, high in organic matter, low in bulk density, and high in capacity to hold water at various tension levels.

### ANDO SOILS

The Ando soils have a thick, almost black, smeary A horizon believed to be rich in allophane. The B horizon is only weakly developed. The Ando soils in the survey area are similar to the Ando soils in Japan. They are mainly well drained, but some are imperfectly drained. (Mr. Masatada Oyama studied a Quillayute profile in 1959 and commented that it was like that of some Japanese Ando soils. Mr. Oyama is chief of Soil Survey, Div. of Soils and Fert., Natl. Inst. Agr. Sci., Japan.)

In the Tillamook survey area, the Ando soils have formed under shrubby grassland in residuum that weathered from basalt and sedimentary rocks and in old alluvium. This is the same type of parent material in which the Sols Bruns Acides have formed. However, the vegetation is obviously not typical for the climate in the survey area. The patchy distribution of the Ando soils suggests that some local, even accidental, factor has been responsible for their formation. Accordingly, even though the Ando soils are considered to be zonal, the evidence for their classification in this order is less compelling than that for the Sols Bruns Acides.

The Quillayute soils are typical of the Ando soils in the survey area. Laboratory analyses (table 7) for these and the Winema soils show that they are high in organic matter and in water-holding capacity at various tension levels, low in bulk density, and low in base saturation.

## PODZOLS

Podzols have an organic horizon at the surface, an eluvial horizon from which humus and iron oxide have been leached, and an illuvial horizon in which humus and iron oxides have accumulated. Cultivation or other disturbances may destroy the two upper horizons. Podzols are mainly well drained, but some are imperfectly drained.

Podzols in the Tillamook survey area are considered to be zonal soils because they are similar to the Podzols that extend across large areas of the northeastern North America and northern Europe and Asia. However, in the Tillamook survey area itself, they have developed in only one kind of parent material that is particularly favorable to the formation of Podzols; therefore, there is little reason to consider them as zonal soils.

Podzols in the Tillamook survey area have formed in dune and beach sands and under shrub vegetation. The Netarts soils are typical locally, but they are weakly developed in comparison to Podzols in other areas.

## Intrazonal soils

Intrazonal soils have developed through soil-forming processes dominated by relief or parent material. In the Tillamook survey area, the great soil groups in the intrazonal order are Humic Gley soils, Low-Humic Gley soils and Bog soils.

### HUMIC GLEY SOILS

Humic Gley soils have a dark-colored surface horizon and gray or mottled lower horizons. They are naturally wet, and wet conditions have dominated in their development. In the Tillamook survey area, these soils are all in the Hebo series, and they have a textural B horizon. Laboratory analyses (table 7) show that they have accumulated organic matter in the surface horizon and have higher base saturation than the soils that are well drained.

### LOW-HUMIC GLEY SOILS

Low-Humic Gley soils are like Humic Gley soils except that the surface horizon is not quite as dark. They are naturally wet, and they have mottled colored patterns and gray colors. In the Tillamook survey area, the only Low-Humic Gley soils are those of the Brenner and Coquille soil series. These are very weakly developed soils because they are in flood-plain and tidal-flat positions where they accumulate continuing additions of recent alluvium.

### BOG SOILS

Bog soils are composed of organic material and have formed under extremely wet conditions. The Brallier soils are typical Bog soils in the Tillamook survey area.

## Azonal soils

Azonal soils have no development, or only weak development, of a profile, mainly because they are young soils. In the Tillamook survey area, Alluvial soils are the only great soil group in the azonal order.

### ALLUVIAL SOILS

Alluvial soils have a weakly expressed A horizon over relatively unaltered alluvium. The Nehalem soils are typical. They have formed in recent alluvium under

coniferous forest or marsh vegetation. Natural drainage is generally good, but it ranges to imperfect.

## Descriptions of Soil Profiles

This part of the report deals with technical profile descriptions of representative soils in the Tillamook survey area. Technical profile descriptions are more detailed than those given in the section "Descriptions of the Soils."

Technical terms used in describing the soils are defined in the Soil Survey Manual (14); some of these terms are also defined in the Glossary at the end of this report. Letters and numerals on the left of the profile designate the horizons in each profile. Combinations of letters and numbers in parentheses, such as (10YR 5/4), are Munsell notations of color—hue, value, and chroma. These notations are more precise than descriptive names of color, which are also given.

### ASTORIA SERIES

Profile of Astoria silt loam in cutover forest, located in SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 24, T. 1 S., R. 8 W., W. M. (Trask cut-off road to access road F. B. 12; down this road 400 feet on right side):

- A00—2 inches to 0, duff consisting of the litter of bracken-fern and the leaves, twigs, and wood of trees.
- A11—0 to 9 inches, very dark grayish-brown (10YR 3/2) silt loam, brown (10YR 5/3) when dry; strong, medium fine and very fine, granular structure; slightly hard, friable, slightly sticky, slightly plastic; many roots; many interstitial pores; medium-size, firm shot common; very strongly acid (pH 4.8); clear, smooth boundary; 7 to 11 inches thick.
- A12—9 to 19 inches, very dark grayish-brown (10YR 3/2) silty clay loam, brown (10YR 5/3) when dry; strong, medium fine and very fine, subangular blocky structure; soft, friable, slightly sticky, plastic; many roots; many interstitial pores; few, patchy, very thin clay films on vertical ped surfaces; few, medium, firm shot; very strongly acid (pH 4.8); clear, smooth boundary; 10 to 12 inches thick.
- B21—19 to 28 inches, dark yellowish-brown (10YR 3/4), light silty clay, yellowish brown (10YR 5/4) when dry; moderate, fine and very fine, subangular blocky structure; slightly hard, friable, sticky, plastic; many roots; few, coarse and medium, tubular pores and many, exceedingly fine interstitial pores; thin, patchy, clay films common; very strongly acid (pH 4.8); clear, wavy boundary; 9 to 13 inches thick.
- B22—28 to 45 inches, dark yellowish-brown (10YR 4/4), light silty clay, light yellowish brown (10YR 6/4) when dry; strong, medium fine and very fine, blocky structure; slightly hard, firm, sticky, plastic; common roots; many, fine and very fine, tubular pores and many, exceedingly fine interstitial pores; many, very thin, patchy clay films on peds and in pores; fine fragments of sedimentary rock common; very strongly acid (pH 4.6); gradual, wavy boundary; 13 to 21 inches thick.
- B3—45 to 50 inches, yellowish-brown (10YR 5/4), heavy silty clay loam, light yellowish brown (10YR 6/4) when dry; moderate, medium and fine, blocky structure; slightly hard, firm, slightly sticky, plastic; common roots; few, coarse to medium, tubular pores and common, fine to very fine, tubular pores; many, thin, patchy clay films on vertical ped surfaces; material is 30 percent medium-size fragments of sedimentary rock; very strongly acid (pH 4.5); clear, wavy boundary; 4 to 8 inches thick.

C—50 to 68 inches, yellowish-brown (10YR 5/6), heavy silty clay loam (color is a mixture of 7.5YR 5/8, 10YR 6/4, and 10YR 7/2, apparently derived from varying rock strata); massive; firm, slightly sticky, plastic; very few roots; material is about 60 percent medium-size fragments of sedimentary rock; very strongly acid (pH 4.8); gradual, wavy boundary; 14 to 22 inches thick.

Dr—68 to 77 inches +, light yellowish-brown (2.5Y 6/4) stratified and broken siltstone coated with dark brown (7.5YR 3/4).

*Range in characteristics:* The soil varies mainly in depth to bedrock, which ranges from less than 3 feet to more than 6 feet. Sandstone or shale fragments in the solum ranges from very few to many. Chroma of the A1 horizon ranges from 2 to 4; thickness of the A horizon ranges from 12 to 22 inches.

### BRALLIER SERIES

Profile of Brallier peat under natural vegetation, located in the NW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 35, T. 1 S., R. 10 W., W. M. (three-fourths of a mile southwest of Tillamook; 100 feet south of witness tree at end of trail, and 200 feet north of the Tillamook River):

- 1—0 to 3 inches, dark-brown (10YR 3/3, when moist) peat containing about 50 percent raw residue of forest litter, spongy moss, wood, and fibrous material and about 30 percent live roots; many, medium, faint to distinct drainage mottles of yellowish brown (10YR 5/8); spongy and porous; no discernible structure; sticky, plastic; extremely acid (pH 4.4); clear, smooth boundary.
- 2—3 to 6 inches, dark grayish-brown (10YR 4/2, when moist) peat containing 50 percent raw residue of wood and fibrous material and 20 percent live roots; many, medium, prominent mottles of strong brown (7.5YR 5/8); spongy and porous; no discernible structure; sticky, plastic; extremely acid (pH 4.2); gradual, smooth boundary.
- 3—6 to 24 inches, grayish-brown (2.5Y 4/2, when moist) peat containing 50 percent raw residue of woody and fibrous material in which live roots are common; many, medium, prominent mottles and many, large, distinct mottles of yellowish red (5YR 5/8); spongy and porous; no structure; very friable, sticky, plastic; extremely acid (pH 4.2); gradual, smooth boundary.
- 4—24 to 38 inches, dark grayish-brown (10YR 4/2, when moist) peat consisting of raw woody and fibrous residue mixed with 20 percent of muck; highly porous and loose; as much as 30 percent interstitial pore space; strongly acid (pH 5.4); gradual, smooth boundary.
- 5—38 to 48 inches, very dark grayish-brown mixture consisting of about 50 percent undecomposed woody and fibrous residue and 50 percent black muck; porous and loose; slightly acid (pH 6.2); gradual, smooth boundary.
- 6—48 to 60 inches, gray muck containing 20 percent undecomposed woody and fibrous residue; slightly compact; slightly acid (pH 6.4).

*Range in characteristics:* The surface layer frequently has colors with chroma of 1. Intermittent and inextensive lenses of sedimentary peat up to 6 inches in thickness occur at various depths below 18 inches from the surface. These lenses are practically impermeable to roots or water. The underlying substrata usually are tidal mud but may be sandy alluvium. When the soil is diked and drained, acidity below depth of 24 inches eventually decreases.

## BRENNER SERIES

Profile of Brenner silt loam in a pasture cleared of trees, located in the NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 17, T. 2 S., R. 9 W. (on the west side of U.S. Highway No. 101, 0.5 mile south of South Prairie store):

- A1p—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; few, fine, distinct mottles of reddish brown; weak, fine, granular structure; friable, slightly sticky, slightly plastic; many roots; strongly acid; clear, smooth boundary; 5 to 8 inches thick.
- A12g—7 to 13 inches, very dark grayish-brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) when dry; common, medium, distinct mottles of strong brown and yellowish red; weak, medium, subangular blocky structure breaking to weak, very fine, subangular blocky; friable, sticky, plastic; many roots; strongly acid; clear, smooth boundary; 5 to 8 inches thick.
- C1g—13 to 21 inches, dark grayish-brown (10YR 4/2) silty clay loam, grayish brown (10YR 5/2) when dry; many, medium, prominent mottles of yellowish red, strong brown, and gray; moderate, medium and fine, subangular blocky structure; firm, sticky, plastic; fine, black shot concretions common; common roots; strongly acid; gradual, smooth boundary; 8 to 12 inches thick.
- C2g—21 to 31 inches, dark grayish-brown (10YR 4/2) silty clay, grayish brown (10YR 5/2) when dry; many, medium, prominent mottles of strong brown and gray; coarse, black splotches common; weak, medium and fine, subangular blocky structure; firm, sticky, plastic; few roots; strongly acid; gradual boundary; 10 to 14 inches thick.
- C1—31 to 40 inches, dark-gray (10YR 4/1) silty clay, gray (10YR 5/1) when dry; many, coarse, distinct mottles of strong brown and light gray; coarse, black splotches common; weak, coarse, subangular blocky structure breaking to weak, fine, blocky; firm, sticky, plastic; no roots; medium acid; clear, smooth boundary; 6 to 12 inches thick.
- G2—40 to 52 inches, dark greenish-gray (5GY 3/1) silty clay, dark gray (5GY 4/1) when dry; many, coarse, distinct mottles of strong brown; massive; firm, sticky, plastic; no roots; slightly acid.

*Range in characteristics:* The base color of the A1 horizon ranges from grayish brown to dark grayish brown when dry. Mottled colors are characteristic of the A1 horizon, but their distinctness varies from place to place. The C and G horizons are distinctly stratified with material whose texture varies in places from coarse to fine. In places the A1 horizon is silty clay loam.

## CHITWOOD SERIES

Profile of Chitwood silt loam in a pasture located in the SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 10, T. 2 S., R. 9 W. (300 feet east of junction of Mill Creek and Brickyard Road):

- A1—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, very fine, granular structure; slightly hard, friable, slightly sticky, slightly plastic; many roots; many interstitial pores; strongly acid (pH 5.2); clear, smooth boundary; 6 to 8 inches thick.
- B1—7 to 11 inches, very dark grayish-brown (10YR 3/2), heavy silt loam, grayish brown (10YR 5/2) when dry; moderate, very fine, subangular blocky structure; slightly hard, friable, sticky, plastic; many roots; thin, patchy clay films on ped surfaces; many fine and medium pores; very strongly acid (pH 5.0); clear, smooth boundary; 3 to 7 inches thick.
- B21—11 to 19 inches, dark-brown (10YR 3/3, moist) silty clay loam; few, fine, faint mottles of dark yellowish brown (10YR 4/4, moist) and yellowish brown (10YR 5/6, moist); moderate, medium, subangular blocky structure breaking to moderate, very fine,

angular blocky; hard, firm, sticky, plastic; thin, continuous clay films on vertical ped surfaces and thin, patchy films on horizontal surfaces; common roots; many fine pores; very strongly acid; clear, smooth boundary; 6 to 10 inches thick.

- B22—19 to 29 inches, dark yellowish-brown (10YR 3/4, moist) silty clay; many, medium, distinct mottles of strong brown (7.5YR 5/6); moderate, medium, subangular blocky structure breaking to moderate, very fine, angular blocky; hard, firm, sticky, plastic; thin, continuous, clay films on ped surfaces and in pores; few medium pores and many fine pores; few roots; very strongly acid (pH 4.8); clear, smooth boundary; 8 to 12 inches thick.
- B3g—29 to 34 inches +, dark yellowish-brown (10YR 3/4, moist) silty clay loam; common, large to medium, prominent mottles of strong brown (7.5YR 5/8) and yellowish red (5Y 5/6); moderate, fine, angular blocky structure; firm, sticky, plastic; thin, patchy clay films common; fine tubular pores common; very strongly acid (pH 4.6).

*Range in characteristics:* Level areas are moderately well drained; those in concave positions are imperfectly drained. Depth to mottled soil ranges from 12 to 24 inches, depending on drainage. Silt loam and silty clay loam types have been recognized.

## COQUILLE SERIES

Profile of Coquille silt loam in a cultivated area located in NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 35, T. 3 N., R. 10 W.:

- Apg—0 to 6 inches, very dark grayish-brown (2.5Y 3/2, moist) silt loam highly mottled with strong brown; moderate, fine, subangular blocky structure breaking to moderate, fine, granular; slightly hard, friable, slightly sticky, slightly plastic; many roots; many fine pores; very strongly acid; clear, smooth boundary; 6 inches thick.
- Alg—6 to 13 inches, dark grayish-brown (2.5Y 4/2, moist) silt loam highly mottled with strong brown and yellowish red; weak, fine, subangular blocky structure breaking to moderate, fine, granular; slightly hard, friable, sticky, slightly plastic; many roots; many fine pores; very strongly acid; clear, smooth boundary; 6 to 10 inches thick.
- C1g—13 to 19 inches, dark grayish-brown (10YR 4/2, moist) silty clay loam highly mottled with strong brown; weak, medium subangular blocky structure; hard, firm, sticky, plastic; many roots; thin layers of peaty organic matter; very strongly acid; gradual, smooth boundary; 5 to 10 inches thick.
- C2g—19 to 40 inches, dark grayish-brown (10YR 4/2, moist) silty clay loam mottled with strong brown and with a few light yellowish-brown splotches of sulfur; weak, medium subangular blocky structure; hard, firm, sticky, plastic; roots common but decreasing to few in lower part; thin lenses of stratified organic matter throughout; very strongly acid; clear, smooth boundary; 15 to 30 inches thick.
- D—40 to 60 inches +, very dark gray (5Y 3/1, moist) silty clay; massive; firm, sticky, plastic; very strongly acid; many feet thick.

*Range in characteristics:* Depth to unconforming clayey marine sediment ranges from 24 to 40 inches. The number of thin, peaty strata varies from place to place.

## GARDINER SERIES

Profile of Gardiner fine sandy loam in a cultivated area located in the NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 36, T. 3 N., R. 10 W. (south of Mohler Bridge on the Nehalem River):

- Ap—0 to 8 inches, dark-brown (10YR 3/3, moist) fine sandy loam; specks of grayish-brown and light brownish-gray on uncoated sand; very weak, fine and me-



dium, subangular blocky structure; soft, very friable, nonsticky, nonplastic; many fine roots; many interstitial pores; strongly acid; clear, wavy lower boundary; 5 to 10 inches thick.

Ac—8 to 34 inches, dark yellowish-brown (10YR 4/4, moist) loamy fine sand; specks of dark brown, brown, light brownish gray, brownish yellow, and dark yellowish brown (10YR 3/3-4/3-6/3-6/2-6/6) on grains of sand; massive; loose, soft, nonsticky, nonplastic; common roots; many interstitial pores; strongly acid; gradual, broken boundary; 20 to 30 inches thick.

C—34 to 60 inches +, dark yellowish-brown (10YR 3/4, moist) loamy fine sand; many specks of grayish brown, light brownish gray, and light gray on grains of sand; single grain; loose, nonsticky, nonplastic; few roots at top, decreasing in number with depth; strongly acid; many feet thick.

*Range in characteristics:* An overwash of different color and texture has been deposited in places by recent floods. Within the profile, strata of coarse sand, fine sand, loamy sand, and silt may be present.

#### GAULDY SERIES

Profile of Gauldy loam in a pasture located in the SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 13, T. 1 N., R. 10 W., W. M. (along Moss Creek, three-quarters of a mile east of confluence with the Miami River, on north side of road; 3 miles east of Garibaldi):

A11—0 to 8 inches, dark-brown (10YR 3/3) loam, brown (10YR 5/3) when dry; moderate, medium and fine, subangular blocky structure; soft, very friable, nonsticky, nonplastic; many roots; many interstitial pores; 10 percent of material is medium-size, water-worn gravel; strongly acid (pH 5.2); clear, smooth boundary; 6 to 10 inches thick.

A12—8 to 26 inches, dark yellowish-brown (10YR 3/4) loam, yellowish brown (10YR 5/4) when dry; moderate, very fine, subangular blocky structure; slightly hard, friable, nonsticky, nonplastic; many roots; many interstitial pores; coarse tubular pores common; 15 percent of material is medium and coarse, water-worn gravel; strongly acid (pH 5.4); abrupt, wavy boundary; 14 to 20 inches thick.

C1—26 to 38 inches, dark yellowish-brown (10YR 3/4) gravelly loamy coarse sand, yellowish brown (10YR 5/4) when dry; loose; nonsticky, nonplastic; coarse roots common; many interstitial pores; 60 percent of material is medium and coarse, waterworn gravel; strongly acid (pH 5.4); clear, wavy boundary; 10 to 14 inches thick.

C2—38 to 55 inches, dark yellowish-brown (10YR 3/4) loamy fine sand, yellowish brown (10YR 5/4) when dry; weak, medium, subangular blocky structure; soft, very friable, nonsticky, nonplastic; few coarse roots; many, fine and medium, tubular pores; 10 percent of material is fine, waterworn gravel; strongly acid (pH 5.4); abrupt, wavy boundary; 14 to 20 inches thick.

D—55 inches +, dark grayish-brown (10YR 4/2) medium and coarse gravelly fine sand, grayish brown (10YR 5/2) when dry; loose; nonsticky, nonplastic; 90 percent of material is gravel; very strongly acid (pH 4.8).

*Range in characteristics:* The amount of gravel in any particular layer is highly variable. A nonconforming layer is typically encountered 4 feet below the surface, but in places it does not occur in the 5-foot profile. The C horizon is typically stratified and may be sandy loam and silt loam with variable amounts of gravel. Enough gravel is generally in this soil to make it droughty. The color of the A1 layer varies from dark brown to black. In places this soil has shallow to nonconforming layers.

#### GINGER SERIES

Profile of Ginger silt loam in a cultivated area located in the SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 29, T. 1 S., R. 9 W., W. M. (0.4 of a mile south of junction of old Highway No. 6 and Marolf Loop Road southeast of fair grounds):

A11p—0 to 8 inches, very dark gray (10YR 3/1) silt loam, black (10YR 2/1) when moist; strong, fine, medium and coarse, granular structure; soft, very friable, nonsticky, slightly plastic; many fine roots; many fine pores; strongly acid; clear, smooth lower boundary; 6 to 9 inches thick.

A12—8 to 17 inches, very dark gray (10YR 3/1) silt loam, black (10YR 2/1) when moist; moderate, fine, subangular blocky structure breaking to strong, fine, granular; soft, friable, slightly sticky, slightly plastic; many roots; many, fine, tubular pores; strongly acid; clear, smooth boundary; 8 to 12 inches thick.

B1—17 to 20 inches, very dark grayish-brown (10YR 3/2, moist) silty clay loam; few, fine, faint mottles of grayish brown and yellowish brown; moderate, medium, subangular blocky structure breaking to strong, very fine, subangular blocky; slightly hard, firm, sticky, plastic; thin, patchy clay films on ped surfaces but pores uncoated; many roots; many fine pores; strongly acid; clear, smooth boundary; 3 to 5 inches thick.

B21g—20 to 28 inches, dark grayish-brown (10YR 4/2, moist) silty clay; many, fine and medium, distinct mottles of light brownish gray and strong brown; moderate, very fine, blocky structure; hard, firm, sticky, plastic; thin, continuous clay films; roots common but decrease in number with depth; medium and very fine pores, few, fine pores common; strongly acid; gradual, smooth boundary; 6 to 12 inches thick.

B22g—28 to 38 inches, grayish-brown (10YR 5/2, moist) silty clay; many, medium and coarse, prominent mottles of strong brown and yellowish red; strong, very fine and fine, blocky structure; hard, firm, sticky, plastic; moderately thick, continuous clay films; few roots; fine pores common; strongly acid; gradual, wavy boundary; 8 to 14 inches thick.

B3g—38 to 52 inches, grayish-brown (2.5Y 5/2, moist) silty clay; many, medium and coarse, prominent mottles of yellowish red and strong brown; moderate, medium, blocky structure breaking to moderate, very fine, blocky; hard, firm, sticky, plastic; thin, patchy clay films; very few roots; few, medium and fine pores; many, small, well-weathered pebbles; strongly acid; 10 to 20 inches thick.

D—52 inches +, compacted gravel.

*Range in characteristics:* Depth to gravel may be as little as 36 inches from surface, but it usually ranges from 48 to 72 inches or is deeper. The A1 horizon is about 15 to 24 inches thick.

#### HEBO SERIES

Profile of Hebo silty clay loam in a cultivated area located in the SE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 33, T. 1 S., R. 9 W., W. M.:

Apg—0 to 4 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) when moist; few, fine faint mottles of strong brown along root channels; moderate, fine and medium, granular structure; hard, firm, sticky, plastic; many fine roots; many, fine tubular pores; very strongly acid (pH 4.5-5.0); clear, smooth boundary; 3 to 6 inches thick.

A1g—4 to 10 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) when moist; many, fine, distinct mottles of strong brown and dark reddish brown; weak, medium, prismatic structure breaking to moderate, very fine and fine, blocky; very hard, very firm, sticky, very plastic; many fine roots; fine pores common; thin, patchy clay films on vertical ped faces and in pores near lower bound-

ary of horizon; very strongly acid (pH 4.5-5.0); clear, smooth boundary; 5 to 10 inches thick.

B21g—10 to 18 inches, dark-gray (5Y 4/1, moist) clay; many, coarse, prominent mottles of strong brown and light brownish gray; moderate, medium, prismatic structure breaking to moderate, coarse and medium, blocky; very hard, very firm, very sticky, very plastic; roots common but decrease in number with depth; few, fine and medium pores; thin, continuous clay films on horizontal faces and thick, stringy clay films on prism faces; few, large, black coatings of manganese dioxide on ped surfaces; few, medium, black shot; very strongly acid; gradual, smooth boundary; 5 to 10 inches thick.

B22g—18 to 28 inches, gray (5Y 5/1, moist) clay; many, coarse, prominent mottles of strong brown; moderate, medium, prismatic structure breaking to strong, fine and medium, blocky; very hard, very firm, very sticky, very plastic; few roots, mainly along ped faces; few, fine pores; moderately thick, continuous clay films; many black coatings of manganese dioxide on peds; black shot common; very strongly acid; gradual, smooth boundary; 6 to 12 inches thick.

B3g—28 to 35 inches, prominently mottled strong-brown (7.5YR 5/8, moist), gray (5Y 5/1, moist), and dark-gray (5Y 4/1, moist) silty clay; weak, fine and medium, subangular and angular blocky structure; firm, sticky, very plastic; very few roots; thin, continuous clay films; few, medium, black splotches of manganese dioxide; very strongly acid; gradual, smooth boundary; 10 to 20 inches thick.

Cg—35 to 42 inches, olive-gray (5Y 4/2, moist) clay loam; many, coarse, prominent mottles of strong brown and gray; massive; firm, sticky, plastic; few water-worn pebbles, some strongly weathered; no roots; no clay films; strongly acid (pH 5.0-5.5).

*Range in characteristics:* Moist color of the A horizon ranges from black to dark gray. Average thickness of A horizon is 10 inches but may be as much as 22 inches in some small areas on which sediment from adjacent hills has been deposited. In a few places the structure grade of the B horizon is weak.

#### HEMBRE SERIES

Profile of Hembre silt loam in logged virgin forest, located in NE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 28, T. 3 S., R. 9 W., W. M.:

A1—0 to 4 inches, dark-brown (7.5YR 4/2) silt loam, dark reddish brown (5YR 3/2) when moist; strong, very fine, granular structure; soft, very friable, non-sticky, slightly plastic; many roots; many fine pores; fine and medium shot common; strongly acid (pH 5.1-5.5); clear, smooth boundary; 3 to 8 inches thick.

A3—4 to 11 inches, dark-brown (7.5YR 4/2) silt loam, dark reddish brown (5YR 3/3) when moist; strong, very fine and fine, granular structure; soft, very friable, slightly sticky, slightly plastic; many roots; many fine pores; fine and medium shot common; strongly acid; clear, wavy boundary; 5 to 10 inches thick.

B21—11 to 17 inches, dark-brown (7.5YR 3/2, moist) silt loam or silty clay loam; weak, very fine and fine, subangular blocky structure breaking to moderate, very fine, granular; soft, friable, slightly sticky, plastic; many roots; few medium shot; thin, continuous clay films; very strongly acid (pH 4.5-5.0); clear, smooth boundary; 4 to 8 inches thick.

B22—17 to 29 inches, reddish brown (5YR 4/3, moist) silty clay loam; weak, medium, subangular blocky structure breaking to moderate, very fine, subangular blocky; hard, firm, sticky, plastic; many roots in upper part, and roots common in lower part; many, fine, tubular pores; thin, continuous clay films; few cobbles and stones; very strongly acid; clear, wavy boundary; 10 to 15 inches thick.

B3—29 to 38 inches, reddish-brown (5YR 4/4, moist) very stony silty clay loam; moderate, very fine and fine,

subangular blocky structure; hard, firm, sticky, plastic; thin, nearly continuous clay films; material is about 60 percent stones; common roots; very strongly acid; abrupt, irregular boundary; 5 to 15 inches thick.

Dr—38 inches +, basic igneous rock.

*Range in characteristics:* In most concave and gently sloping areas, the profiles are weathered deeply. On convex slopes and on very steep slopes, the Hembre soils are moderately deep. Most profiles contain some stones. The lower part of the B horizon is more than 50 percent stones in some areas. The B horizon ranges in texture from silt loam to silty clay loam and in color from reddish brown to yellowish brown.

#### KILCHIS SERIES

Profile of Kilchis stony loam in a burned area located in the SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 17, T. 1 N., R. 8 W., W. M.:

A00—2 $\frac{1}{2}$  inches to 0, litter consisting of fresh and partially decomposed organic residue.

A—0 to 5 inches, dark reddish-brown (5YR 3/2, moist) silt loam, reddish gray (5YR 5/2) when dry; moderate, very fine, granular structure; friable, nonsticky, nonplastic; abundant roots; abundant interstitial pores; 25 percent of volume is rock; many fine shot; strongly acid (pH 5.0); clear, wavy boundary; 4 to 8 inches thick.

AC—5 to 12 inches, dark reddish-brown (5YR 3/3, moist) silt loam, reddish brown (5YR 5/3) when dry; strong, very fine, granular structure; very friable, nonsticky, nonplastic; abundant roots; many, medium, interstitial pores; 50 percent of volume is angular rock; fine shot common; very strongly acid (pH 4.8); clear, wavy boundary; 5 to 9 inches thick.

C—12 to 20 inches, dark reddish-brown (5YR 4/4, moist) silt loam, light reddish brown (5YR 6/4) when dry; weak, fine, granular structure; friable, slightly sticky, nonplastic; many roots; many interstitial pores; manganese stains on rock fragments; 85 percent of volume is angular rock; very strongly acid (pH 4.8); irregular boundary; 4 to 10 inches thick.

Dr—20 inches +, shattered, fine-grained, basic igneous basalt rock.

*Range in characteristics:* Rock in the solum ranges from 50 to 90 percent. The AC and C horizons vary greatly in thickness, texture, and structure.

#### KNAPPA SERIES

Profile of Knappa silt loam in a cultivated area located in the NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 21, T. 2 S., R. 9 W., W. M. (east side of U.S. Highway No. 101, 2 miles south of South Prairie store):

A11p—0 to 7 inches, dark-brown (10YR 3/3) silt loam, very dark brown (10YR 2/2) when moist; moderate, fine and very fine, granular structure; soft, friable, non-sticky, slightly plastic; many fine roots; many, fine and medium pores; few, fine, shot concretions; very strongly acid (pH 4.5-5.0); clear, smooth boundary; 6 to 8 inches thick.

A12—7 to 14 inches, very dark grayish-brown (10YR 3/2, moist) silt loam; strong, very fine, subangular blocky structure; soft, friable, slightly plastic, non-sticky; many fine roots; fine pores common; few, medium, shot concretions; very strongly acid; clear, smooth boundary; 5 to 10 inches thick.

B1—14 to 18 inches, dark-brown (10YR 3/3, moist) silty clay loam; strong, very fine, subangular blocky structure; soft, firm, slightly sticky, plastic; fine roots common; thin, patchy, clay films; very strongly acid; clear, smooth boundary; 3 to 5 inches thick.

B21—18 to 27 inches, dark-brown (10YR 3/3, moist) silty clay loam; strong, very fine, subangular blocky

structure; firm, sticky, plastic; roots common, but decrease in number with depth; thin, continuous clay films; clear, smooth boundary.

- B22—27 to 48 inches, dark yellowish-brown (10YR 3/4, moist) silty clay loam; moderate, very fine and fine, subangular blocky structure; firm, sticky, plastic; roots common but decrease to few in lower part; thin, continuous clay films; very strongly acid; gradual, smooth boundary; 15 to 30 inches thick.
- B3—48 to 60 inches +, dark yellowish-brown (10YR 4/4, moist) silty clay loam; moderate, medium and fine, subangular blocky structure; firm, slightly sticky, plastic; few roots; thin, continuous clay films; very strongly acid.

*Range in characteristics:* The color of the A1 horizon ranges from very dark brown to dark brown; that of the B horizon, from dark brown to yellowish brown. Fine mottles are in the lower B horizon, near the boundary with the Chitwood soils. Slightly weathered gravel may occur at a depth of 3 to 5 feet. This gravel is unrelated to the soil parent material. Depth-to-gravel phases are recognized.

#### MEDA SERIES

Profile of Meda gravelly loam in a cultivated area located in the SE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 36, T. 3 S., R. 10 W. (300 feet north of Simmons 101 Camp, along U.S. Highway No. 101):

- Ap—0 to 9 inches, dark grayish-brown (10YR 4/2) gravelly loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, subangular blocky structure breaking to moderate, very fine, granular; soft, friable, nonsticky, nonplastic; many roots; fine, tubular pores common; medium acid (pH 5.6–6.0); clear, smooth boundary; 5 to 11 inches thick.
- AC—9 to 24 inches, grayish-brown (10YR 5/2) gravelly clay loam, dark brown (10YR 3/3) when moist; weak, very fine and fine, subangular blocky structure; soft, friable, slightly sticky, slightly plastic; many fine roots, but number decreases with depth; many, fine and medium tubular pores; many pebbles and fragments of shale; medium acid; gradual, smooth lower boundary; 10 to 20 inches thick.
- C—24 to 36 inches +, dark-brown (10YR 4/3, moist) sandy loam; massive; soft, friable, nonsticky, nonplastic; few, fine roots; many, fine pores; pebbles and fragments of shale common; medium acid; many feet thick.

*Range in characteristics:* The thickness of the A horizon may vary markedly within a short distance, depending on amount of recent local deposition. Gravel content is variable; some areas are nearly free of gravel. In places a few cobbles and stones are in the profile.

#### NEHALEM SERIES

Profile of Nehalem silt loam in a cultivated area located in SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 34, T. 1 S., R. 9 W., W. M. (0.4 of a mile south of Johnson Bridge):

- Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2), dark brown (10YR 4/3) when dry; moderate, fine, subangular blocky structure breaking to moderate, very fine, granular; soft, very friable, nonsticky, nonplastic; many roots; strongly acid (pH 5.0–5.5); clear, smooth boundary; 6 to 8 inches thick.
- C1—8 to 17 inches, dark-brown (10YR 4/3, moist) silt loam; weak, fine, subangular blocky structure breaking to moderate, very fine, granular; soft, friable, slightly plastic, nonsticky; many roots; strongly acid; clear, smooth boundary; 5 to 10 inches thick.
- C2—17 to 37 inches, dark-brown (10YR 4/3, moist) silty clay loam; strong, fine and very fine, blocky structure; firm, slightly sticky, plastic; common roots;

very strongly acid (pH 4.5–5.0); gradual, smooth boundary; 15 to 25 inches thick.

- C3—37 to 60 inches +, dark-brown (10YR 4/3, moist) silty clay loam; moderate, very fine, blocky structure; firm, sticky, plastic; roots common in upper part, few in lower part; very strongly acid.

*Range in characteristics:* Stratification of the C horizon is common; layers and lenses of sandy material occur at any depth. Stratification is most pronounced in areas subject to frequent flooding. Faint, gray and strong-brown mottles occur in the lower substratum near boundaries with the more poorly drained associated soils. In places an unrelated stratum of gravel underlies the profile, and depth phases may be recognized.

#### NESKOWIN SERIES

Profile of Neskowin silty clay loam in a pastured area located in NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 18, T. 5 S., R. 10 W. (south-east of the quarry on U.S. Highway No. 101, opposite Winema Beach):

- A11—0 to 5 inches, very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) when moist; strong, very fine and fine, granular structure; slightly hard, friable, sticky, plastic; many roots; many fine pores; strongly acid; clear, smooth boundary; 3 to 8 inches thick.
- A12—5 to 12 inches, very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) when moist; strong, very fine, subangular blocky structure breaking to strong, very fine, granular; slightly hard, friable, sticky, plastic; many roots; few, medium pores but many, fine and very fine pores; strongly acid; clear, smooth boundary; 5 to 15 inches thick.
- B1—12 to 17 inches, dark reddish-brown (5YR 2/2, moist) silty clay loam; strong, very fine, subangular blocky structure breaking to weak, fine, granular; slightly hard, friable, sticky, plastic; many roots; fine and very fine pores common; thin, patchy clay films on vertical ped surfaces; few, fine shot concretions; very strongly acid; clear, smooth boundary; 3 to 10 inches thick.
- B2—17 to 27 inches, dark-brown (7.5YR 3/2, moist) silty clay loam; moderate, medium, subangular blocky structure breaking to moderate, very fine, subangular and angular blocky; slightly hard, friable, sticky, very plastic; thin, continuous clay films on ped surfaces and in pores; few, medium-size pores, common fine pores; very strongly acid; abrupt, irregular boundary; 8 to 30 inches thick.
- Dr—27 inches +, basic igneous bedrock.

*Range in characteristics:* Earth slips, mass earth movements, and irregularities in the original bedrock surface make the depth to bedrock variable. Stones may occur in any horizon.

#### NESTUCCA SERIES

Profile of Nestucca silt loam in a cultivated area located in the NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 3, T. 2 S., R. 9 W. (0.6 of a mile south of the Johnson Bridge, across the Trask River):

- A11p—0 to 6 inches, brown (10YR 4/3) silt loam, dark brown (10YR 3/3) when moist; moderate, very fine, granular structure; soft, very friable, nonsticky, nonplastic; many roots; many, fine and very fine tubular pores; pH 5.2; clear, smooth boundary; 4 to 7 inches thick.
- A12—6 to 14 inches, very dark grayish-brown (10YR 3/2, moist) silt loam; moderate, fine, granular structure; soft, friable, nonsticky, nonplastic; many fine roots; many fine tubular pores; pH 5.2; clear, smooth boundary; 3 to 8 inches thick.

B2—14 to 41 inches, dark grayish-brown (10YR 4/2, moist) silty clay loam; many, medium, distinct mottles of reddish brown; moderate, fine, subangular blocky structure; slightly hard, firm, sticky, plastic; common roots; fine tubular pores common; clay films absent; pH 5.0; gradual, smooth boundary; 15 to 30 inches thick.

C—41 to 60 inches +, dark-gray (10YR 4/1, moist) silty clay; many, coarse, prominent mottles of dark reddish brown; massive or weak, medium, subangular blocky structure; hard, firm, very sticky, very plastic; very few roots; few, very fine pores; clay films absent; pH 4.8.

*Range in characteristics:* The contrast of mottling in the B horizon ranges from faint to distinct. Where this soil grades toward the Brenner soils, the reddish-brown mottles disappear, and the B horizon becomes grayer. The amount of clay in the B horizon varies. Texture of the B horizon ranges from heavy silt loam to silty clay loam.

#### NETARTS SERIES

Profile of Netarts fine sandy loam in a virgin forest located in the NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 31, T. 1 S., R. 10 W. (one-half of a mile northwest of Netarts, Oregon):

A00—1½ inches to 0, litter consisting of an accumulation of leaves, twigs, and limbs from deciduous trees and low-growing shrubs.

A0, A2—0 to 3 inches, very dark brown (10YR 2/2) fine sandy loam, black (10YR 2/1) when moist; many clean sand grains of gray and light brownish gray; massive; very soft, very friable, nonsticky, nonplastic; many roots; many interstitial pores; extremely acid; abrupt, wavy, lower boundary with thin tongues extending into the A2 horizon along old root channels; 1 to 4 inches thick.

A2—3 to 7 inches, mixed dark grayish-brown (2.5Y 4/2, moist), grayish-brown (2.5Y 5/2, moist), light brownish-gray (2.5Y 6/2, moist), and light-gray (10YR 6/1, moist) loamy fine sand; thin tongues of darker material from horizon above; massive; very friable, nonsticky, nonplastic; many roots; many, fine interstitial pores; very strongly acid; clear, wavy boundary; 1 to 5 inches thick.

AB—7 to 13 inches, mixed grayish-brown (2.5Y 5/2, moist), light brownish-gray (2.5Y 6/2, moist), and light yellowish-brown (2.5Y 6/4, moist) loamy fine sand showing patches of dark brown; massive; very friable, nonsticky, nonplastic; few, soft, iron-cemented nodules stained with dark brown; common to few roots; strongly acid; clear boundary; 4 to 12 inches thick.

B2lr—13 to 17 inches, mottled dark-brown (7.5YR 3/2 and 4/4, moist), light brownish-gray (2.5Y 6/2, moist), and light yellowish-brown (2.5Y 6/4, moist) fine sand; massive; soft, very friable, nonsticky, nonplastic; hard lenses of iron-rich material; very few roots; many, fine interstitial pores; strongly acid; clear, wavy boundary; 3 to 5 inches thick.

B2m—17 to 35 inches, mottled reddish-brown (5YR 4/4, moist), dark-brown (7.5YR 3/2, moist), and grayish-brown (2.5Y 5/2, moist) fine sand; massive; weakly cemented, some fragments and nodules strongly cemented; firm and very firm, nonsticky, nonplastic; roots few but absent in lower part; strongly acid; gradual, wavy boundary; 10 to 20 inches thick.

B3—35 to 52 inches, mottled yellowish-brown (10YR 5/4, moist), grayish-brown (2.5Y 5/2, moist), and light brownish-gray (2.5Y 6/2, moist) fine sand; massive; very friable, nonplastic, nonsticky; few weakly cemented fragments and nodules; no roots; strongly acid; gradual, wavy boundary; 10 to 20 inches thick.

C—52 to 65 inches +, mottled dark grayish-brown (2.5Y 4/2, moist), grayish-brown (2.5Y 5/2, moist), light yellowish-brown (2.5Y 6/4, moist), and pale-yellow (2.5Y 7/4, moist) fine sand; massive; very friable, nonsticky, nonplastic; strongly acid; many feet thick.

*Range in characteristics:* Texture ranges from sandy loam to fine sand. In some places the A2 horizon lies directly below the A00 and the very thin A0 horizon. Hard material in the B horizon varies from thin stratified layers to thick massive layers that are weakly to strongly cemented.

#### QUILLAYUTE SERIES

Profile of Quillayute silt loam in a cultivated area located in the SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 13, T. 1 S., R. 10 W.:

A1p—0 to 9 inches, very dark gray (10YR 3/1, dry) to black (10YR 2/1, moist) silt loam; moderate, fine and very fine, subangular blocky structure breaking to strong, very fine, granular; soft, friable, slightly plastic, slightly sticky; abundant roots; numerous very fine pores; very strongly acid (pH 4.6); clear, smooth boundary; 8 to 9 inches thick.

A3—9 to 21 inches, very dark gray (10YR 3/1) to black (10YR 2/1, moist) silt loam; weak, very fine, subangular blocky structure breaking to moderate, very fine, granular; soft, friable, slightly sticky, slightly plastic; very thin, patchy clay films on vertical ped surfaces in the lower part of the horizon; abundant roots; abundant fine pores; very strongly acid (pH 4.6); clear, smooth boundary; 10 to 15 inches thick.

B1—21 to 30 inches, very dark grayish-brown (10YR 3/2, moist) silt loam to silty clay loam; moderate, very fine, subangular blocky structure that breaks to weak, fine, granular; soft, friable, slightly sticky, slightly plastic; common roots; common fine pores; very thin, patchy clay films on peds; pores clean; extremely acid (pH 4.4); gradual, smooth boundary; 8 to 10 inches thick.

B2—30 to 48 inches, dark yellowish-brown (10YR 4/4, moist) silt loam to silty clay loam; moderate, very fine, subangular blocky structure that breaks to weak, fine, granular; soft, friable, slightly sticky, slightly plastic; common roots; common fine pores; very thin, patchy clay films on peds; pores clean; extremely acid (pH 4.4); gradual, wavy boundary; 15 to 25 inches thick.

B3—48 to 60 inches +, light yellowish-brown (10YR 5/4, moist) silt loam to silty clay loam; weak, medium, subangular blocky structure breaking to moderate, very fine, subangular blocky; soft, friable to firm, sticky, plastic; few, thin, patchy clay films on peds; extremely acid (pH 4.4); very few roots.

*Range in characteristics:* The solum may have gravel and cobbles throughout the profile or it may be moderately deep over a gravelly layer. The A horizon may range in thickness from 18 to 24 inches. Where the Quillayute soils intergrade toward the poorly drained members of the catena, gray colors and faint mottles are in the lower B horizon. The soil usually has a large quantity of worm casts throughout.

#### TRASK SERIES

Profile of Trask clay loam in a burned forest located in the northeast corner of the NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 36, T. 1 N., R. 8 W., W. M. (0.8 of a mile up the Cedar Butte Lookout Road (west) from the Tillamook-Portland Highway to parking space):

A00—3 inches to 0, litter of plant material.

A11—0 to 5 inches, dark-brown (7.5YR 3/2, moist) shaly loam, brown (7.5YR 5/2) when dry; 40 percent of layer con-



sists of shale fragments; weak, very fine, granular structure; very friable, nonsticky, nonplastic; abundant roots; abundant, fine interstitial pores; partially decomposed organic residue abundant; very strongly acid (pH 4.8); clear, wavy boundary; 4 to 7 inches thick.

A12—5 to 8 inches, dark-brown to dark yellowish-brown (10YR 3/3 to 3/4, moist) shaly silt loam, brown (10YR 5/3) when dry; strong, fine, granular structure; friable, nonsticky, slightly plastic; abundant roots; abundant interstitial pores; partially decomposed and some charred organic residue abundant; 40 percent of layer is shale fragments; very strongly acid (pH 4.8); clear, irregular boundary; 2 to 6 inches thick.

B2—8 to 14 inches, strong-brown to dark yellowish-brown (7.5YR 5/6-10YR 4/4, moist) shaly silt loam, light yellowish brown (10YR 6/4, dry); weak, fine, subangular blocky structure; friable, slightly sticky, plastic; common roots; common interstitial pores; 70 percent of layer is shale fragments; complex of bedrock with soil in pockets and layers; very strongly acid (pH 4.6); gradual, broken boundary; 4 to 11 inches thick.

C—14 to 28 inches, yellowish-brown (10YR 5/4 to 5/6, moist) to dark-brown and strong-brown (7.5YR 4/4 and 5/8, moist) shaly silt loam; variegated color influenced by shale bedrock; weak, fine, subangular blocky structure; friable, sticky, plastic; few roots; few, medium and large, interstitial pores; 85 percent of layer is shale fragments; complex of bedrock with soil in pockets and in old root channels; very strongly acid (pH 4.6); manganese stains or charred organic-matter stains on many shale fragments.

R—28 inches +, highly fractured silty sedimentary beds with occasional roots extending to a depth of 48 inches.

*Range in characteristics:* Shale fragments in the surface horizon range from 30 to 90 percent of volume. The subsurface layers vary in texture from a loam to clay loam and in thickness from very thin to as much as 30 inches. Shale outcrops cover as much as 25 percent of the surface area.

#### WINEMA SERIES

Profile of Winema silt loam in a cultivated area located in the NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 34, T. 1 S., R. 9 W. (on slope, north of Red Clover Cheese Factory):

A11—0 to 10 inches, very dark gray (10YR 3/1) silt loam, black (10YR 2/1) when moist; strong, very fine, fine, and medium, granular structure; soft, friable, slightly sticky, slightly plastic; many fine roots; many, fine and medium tubular pores; very strongly acid (pH 4.5-5.0); clear, wavy boundary; 6 to 12 inches thick.

A12—10 to 21 inches, very dark gray (10YR 3/1) silt loam, black (10YR 2/1) when moist; moderate, fine, subangular blocky structure breaking to strong, fine and very fine, granular; soft, friable, slightly sticky, slightly plastic; many fine roots; many, fine and medium pores; very strongly acid; clear, wavy boundary; 6 to 12 inches thick.

B1—21 to 28 inches, dark-brown (10YR 3/3, moist) silty clay loam; strong, very fine and fine, subangular blocky structure; slightly hard, firm, sticky, plastic; many roots; thin, continuous clay films; very strongly acid; clear, wavy boundary; 5 to 10 inches thick.

B2—28 to 42 inches, dark yellowish-brown (10YR 4/4, moist) silty clay; strong, fine, subangular blocky structure;

hard, firm, sticky, plastic; roots common but decrease in number with depth; moderately thick, continuous clay films; some brown weathered fragments of shale; very strongly acid; gradual, smooth boundary; 10 to 20 inches thick.

C—42 to 60 inches +, mottled yellowish-brown (10YR 5/4, moist) and grayish-brown (2.5Y 5/2, moist) silty clay; very weak, coarse, subangular blocky structure, or massive; few, patchy, clay films on ped surfaces; many weathered fragments of shale; very strongly acid.

*Range in characteristics:* Depth to parent rock ranges from about 24 to about 80 inches. The shale layer has weathered several feet deep. The thickness of A horizon ranges from 15 to 30 inches. It is thickest on lower slopes.

#### YAQUINA SERIES

Profile of Yaquina loamy fine sand in an undisturbed area located in the SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 28, T. 3 N., R. 10 W., W. M. (Bayside Garden area of Nehalem, Oreg., 1,200 feet south of U.S. Highway No. 101 and 300 feet east of north-south road, one-half of a mile west of Nehalem):

A00—1½ inches to ½ inch, litter consisting of leaves, needles, twigs, and limbs of shore pine, spruce, and associated deciduous trees and low shrubs.

A0—½ inch to 0, very dark gray (10YR 3/1) when moist; decomposed plant remains sprinkled with white grains of sand; extremely acid (pH 4.5).

A2—0 to 6 inches, gray (10YR 5/1) loamy fine sand, light gray (10YR 7/1) when dry; single grain; loose, nonplastic, nonsticky; many roots; many interstitial pores; very strongly acid (pH 4.8); clear, wavy boundary; 4 to 8 inches thick.

B21r—6 to 14 inches, dark grayish-brown (2.5Y 4/2) fine sand, light brownish gray (2.5Y 6/2) when dry; many sand grains of olive brown and light olive brown; fine, faint, distinct mottles common; very weak, coarse and medium, subangular blocky structure; very soft, very friable, nonsticky, nonplastic; firm, iron-cemented nodules common; roots common; few, medium tubular pores and many, fine interstitial pores; very strongly acid (pH 5.0); gradual, wavy boundary; 6 to 12 inches thick.

B22ir—14 to 30 inches, grayish-brown (2.5YR 5/2) fine sand; sand grains of olive brown (2.5Y 4/4) and light brownish gray (2.5Y 6/2) (all colors in this horizon measured when moist); single grain; loose, nonsticky, nonplastic; common, large, faint mottles and a few, medium, distinct mottles of pale brown (10YR 6/3) and yellowish brown (10YR 5/6); few roots; medium and fine, soft, iron-cemented nodules common; strongly acid (pH 5.4); gradual, wavy boundary; 12 to 20 inches thick.

C—30 to 42 inches +, variegated grains of sand colored light olive-brown (2.5Y 5/4, moist); pale brown (10YR 6/3, moist), dark reddish-gray (5YR 4/2, moist), and pinkish-gray (5YR 6/2, moist); single grain; loose, nonsticky, nonplastic; strongly acid (pH 5.2); many feet thick.

*Range in characteristics:* The A2 horizon ranges from very thin to thick (10 inches) within a horizontal distance of only a few yards. This horizon loses its identity when it is disturbed in cultivation. In many places medium- and fine-textured marine sediment underlies the sand. The degree of cementation of nodules in the B horizon varies from place to place. The number and degree of drainage mottles are variable.

## General Nature of the County<sup>6</sup>

This section is provided mainly for readers who are not familiar with Tillamook County, or the survey area. It describes the environment, history, facilities, and agriculture of the county.

## Physiography, Relief, and Drainage

Tillamook County landscape is characterized by broad, coastal valleys; a narrow, discontinuous coastal plain up to 4 miles wide; an old, dissected plateau composed of sedimentary rock; and monadnocks composed of basalt bedrock, which protect the underlying sedimentary material and form the backbone of the Oregon Coast Range and of all promontories in Tillamook County (7).

The old, dissected, moderately high hills that lie along the western flank of the Oregon Coast Range and that border the coastal plain are an upraised peneplain composed of sedimentary rock (12). Elevations increase gradually, and the valleys become narrower as they extend toward the eastern boundary of Tillamook County. In this part of the county, summits along the youthfully dissected crest of the coast range have an elevation of more than 3,500. The coast line is relatively straight and has moderately broad sandy beaches between isolated, rugged volcanic headlands.

Outcropping formations consist of beds of sedimentary rocks more than 20,000 feet thick laid down in marine and brackish water. In addition, there are interbedded volcanic materials that typically intrude in sills, or in sill-like bodies, ranging from a few feet to 500 feet and more in thickness. Mount Hebo, Mount Gauldy, Saddle Mountain, and Scott Mountain all owe their elevations to a protective igneous cap. These Tertiary formations range in age from lower Eocene to middle Miocene, and they are overlain along the coast by unconsolidated terrace and estuarine materials of Pleistocene age.

The drainage in Tillamook County is through seven rivers that flow west. The flood plains and alluvial terraces are concentrated near the mouths of these rivers and extend upstream for various distances to about 7 miles from the coast. The flood plains occupied by soils of the Nehalem-Brenner-Coquille association and by those of the Netarts association have an elevation of less than 40 feet. The extensive alluvial terraces occupied by soils of the Quillayute-Knappe-Hebo association have elevations up to 80 feet.

The interfluvial fingers of basalt in the Hembre-Astoria association start at the coast, separate each watershed, and slope steeply to an elevation of 1,000 feet or more above sea level. These fingers of basalt extend inland for 8 to more than 21 miles to the crest of the Oregon Coast Range and to elevations of 3,500 feet. Valleys that extend into the Astoria-Hembre soil association, which is underlain by sedimentary bedrock, become narrow and are flanked by narrow flood plains and very narrow stringer terraces. The side slopes are steep and moderately long and extend to the smoothly shaped uplands.

Drainageways that extend into the Hembre-Kilchis-Astoria-Trask association have a steep gradient. The side slopes are long and precipitous and usually extend to the crest. The material of these slopes is generally a "cap" overlying formations that weather into landscapes with angular contours typical in uplands formed of basic igneous rock.

## Natural Cover

Three general types of vegetative cover are in Tillamook County. Shrub-grass vegetation is on soils of uplands near the coast. Brackenfern is the main plant, and it contributes a large amount of organic residue that is high in lignin and other compounds that resist decomposition by the microfauna and microflora in the soil. The residue accumulates as inert, sooty, carbonaceous material. Soils containing 15 to 20 percent organic matter from brackenfern are very strongly acid and moderately low in fertility. Shrub-grass cover dominates in the Winema-Neskowin soil association and, to a lesser degree, the Quillayute-Knappe-Hebo association.

Low, water-loving trees and other vegetation grow on the imperfectly to very poorly drained bottom lands. A high water table confines plant roots to the shallow, surface layer of the soils. Soils in these areas are usually very strongly acid and have a much higher natural fertility than soils under brackenfern. Uncleared and undrained parts of the Nehalem-Brenner-Coquille association have a natural cover of water-loving plants.

The forest type of vegetation is on soils of the uplands. Trees are rooted deeply in the soil. Roots exert a mixing action in the soil, so that fragments of material are subjected to chemical and biological weathering.

The main native forest trees in the Tillamook survey area are Douglas-fir (*Pseudotsuga menziesii*); shore (lodgepole) pine (*Pinus contorta*); western redcedar (*Thuja plicata*); Sitka spruce (*Picea sitchensis*); western hemlock (*Tsuga heterophylla*); red alder (*Alnus rubra*); Oregon crabapple (*Malus diversifolia*); Scouler (mountain) willow (*Salix scouleriana*); Pacific (black) willow (*S. lasiandra*); peachleaf willow (*S. amygdaloides*); black cottonwood (*Populus trichocarpa*); cascara buckthorn (*Rhamnus purshiana*); bigleaf maple (*Acer macrophyllum*); black (Douglas) hawthorn (*Crataegus douglasii*); and Port-Orford-cedar (*Chamaecyparis lawsoniana*) (introduced in the Tillamook survey area).

## Forest Land

Tillamook County is 93 percent forest land. Forests are the major source of income, even though a large part of them has been damaged by repeated fires. Industries dependent on timber as raw material employ 82 percent of all workers engaged in manufacturing (10). More than 99 percent of the county's forest land—670,000 acres—is classed as commercial forest. The remaining 1 percent is productive but is in State parks and Federal lighthouse reserves.

The Douglas-fir type makes up 34 percent of forest land; the hemlock-Sitka spruce type, 28 percent; hardwoods, 15 percent; other softwoods, 1 percent; and the

<sup>6</sup> CARL SCHMADEKE, work unit conservationist of the North Tillamook Soil Conservation District, assisted in writing this section.

area not stocked with forest trees, 22 percent. Fire and logging have reduced the area of sawtimber to 276,000 acres. Of this area, 183,000 acres is in large sawtimber and the rest is in small sawtimber. The area in large, old-growth Douglas-fir, which once covered most of the county, has been reduced to 9,000 acres.

Pole timber occupies 68,000 acres; stands of seedlings and saplings, 176,000 acres. Trees in these sizes are mainly in the area burned by the Tillamook fires. The acreage not stocked with forest trees is almost all inside the burned area.

### **Ownership**

Nearly all the land that was privately owned before the Tillamook fires—245,000 acres—has reverted to the county for nonpayment of taxes. Some of the former owners have retained their rights to cut timber, and full title to the land will be obtained by the county when the owners complete the salvage of merchantable material. Large areas of this tax delinquent land have been given to the State, so that almost half the acreage of commercial forest land is now owned by the State of Oregon.

The area owned by the U.S. Government has changed very little for a long time. The United States owns slightly more than one-fifth of the commercial forest land in the county. Of this area, nearly two-thirds is in the Siuslaw National Forest.

Private owners control about one-third of the commercial forest-land acreage; county and municipal governments control about 1 percent.

### **Utilization**

The Tillamook fires of 1933, 1939, and 1945 killed 13 billion board feet of old-growth timber. Since 1933, the salvage of fire-killed timber has been more important than the harvesting of live timber. In 1952, 447 million board feet of dead timber was harvested. During the period 1953–1955, owners salvaged an average of 283 million board feet of timber per year, or about 68 percent of the county's total saw-log production in the same period.

Since the 1930's, the supply of sawtimber in the Columbia River area of northwestern Oregon and southwestern Washington has gradually decreased. This has created a market for timber killed by the Tillamook fires. During this period, the merchantability standards for logs have gradually been lowered. This has allowed owners to log burned-over areas three to four times for salvageable material. Salvage operations continue on a large scale to the present time.

The expanding pulp industry in the Pacific northwest has created a large demand for the county's Sitka spruce and hemlock timber. Because of the rapidly growing plywood industry, plywood is one of the main products manufactured.

### **Reforestation**

The Tillamook fires and subsequent publicity about them have caused the public to demand rehabilitation of the burned area and prevention of similar holocausts in the future. Rehabilitation was started in 1949 with money provided by a bond issue authorized by public

vote in 1948. This program consists of felling snags, reforestation through aerial seeding and through hand planting of areas suited to each method, and developing a system of fire protection. To date, about 40,000 acres have been seeded, and about 23,000 acres have been planted with 17 million seedlings. Fire protection consisted of building 90 miles of firebreaks and eleven lookout stations. Most of the nonstocked areas are either still being logged or have a potential logging value and will be turned over to the State when logging is completed. Land is not reforested until logging has been completed.

### **Future forests**

Studies indicate that Douglas-fir, hemlock, and spruce are growing at rates better than the regional average for these species. The active seeding and planting program, the rapid rate of tree growth, the expanding market, and the excellent accessibility to market are favorable for the wood-using industries in Tillamook County. Yields from forests may not be so high in the future as they have been in the past because supplies of salvageable timber are about used up.

Sales of standing timber have a material effect on the county's prosperity, and they are the main source of money for paying the costs of county government. The county gets a stipulated percentage of the income derived from the sale of timber on lands owned by the State and Federal Governments.

### **Climate**

Westerly winds predominate and carry the modifying effect of the ocean over the whole county. Summers are cool and winters are moderate. Relative humidity is high most of the time. Temperatures of 90° F. or more occur on an average of only one day per year.

Freezing temperatures have been recorded every month of the year except in July and August. Temperature as low as zero has never been recorded. Data from the Tillamook Station show the latest frost in spring occurred on June 29; the earliest in fall, September 25. The average date of the last frost in spring is May 5; the earliest in fall, November 3; and the average length of the frost-free season is 182 days. Table 8 shows climatic data for two U.S. Weather Bureau stations in Tillamook County—Tillamook and Cloverdale.

Tillamook County is in an area of heavy rainfall. Most of the year's precipitation falls in the period of November through March. The months of June, July, and August are dry. An average of only about 6 inches of rain falls during these three months. The fall of snow averages 5.4 inches per year but has been as much as 19 inches. Usually there are three to six light snows a season, which melt within a few hours.

Winds blow nearly continuously throughout the year, and at times during the winter months reach gale velocities. The prevailing winds are from the northwest during summer and from the south and southwest during winter.

Tillamook County has a very definite winter-rainfall type of climate.

TABLE 8.—*Temperature and precipitation at two stations in Tillamook County, Oreg.*

TILLAMOOK STATION [Elevation, 15 feet; prior to 1953, 40 feet]							
Month	Temperature <sup>1</sup>			Precipitation <sup>2</sup>			
	Average	Absolute maximum	Absolute minimum	Average	Driest year <sup>3</sup>	Wettest year <sup>3</sup>	Average snowfall
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
January.....	42.5	72	1	13.48	12.59	7.51	2.9
February.....	44.3	78	5	11.59	5.68	21.53	.8
March.....	45.7	83	19	10.74	3.33	19.01	.8
April.....	48.4	86	26	6.36	4.62	7.97	.1
May.....	52.0	95	24	5.17	8.16	7.81	( <sup>4</sup> )
June.....	55.8	101	33	3.16	1.48	3.83	0
July.....	58.8	98	33	1.33	.54	4.09	0
August.....	58.9	94	34	1.48	.47	.95	0
September.....	56.4	98	30	4.18	1.98	4.44	0
October.....	52.9	92	24	7.28	3.66	5.34	( <sup>4</sup> )
November.....	47.9	81	16	13.51	8.00	23.18	.1
December.....	44.0	77	0	15.22	13.08	26.47	.5
Year.....	50.6	101	0	93.50	63.59	132.13	5.2

CLOVERDALE 1 NW. STATION [Elevation, 20 feet]							
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
January.....	41.4	62	8	10.62	6.92	11.35	3.5
February.....	44.7	72	16	11.12	9.09	12.80	.7
March.....	45.9	80	25	10.47	5.24	13.27	.8
April.....	49.1	89	27	5.70	7.09	8.18	( <sup>4</sup> )
May.....	53.2	93	32	4.36	3.48	5.55	( <sup>4</sup> )
June.....	56.9	90	36	3.18	2.45	.66	0
July.....	60.4	96	38	1.14	.17	.63	0
August.....	60.1	98	38	1.39	.82	.72	0
September.....	58.3	95	34	3.38	3.41	7.85	0
October.....	53.7	87	28	7.48	4.91	3.27	( <sup>4</sup> )
November.....	47.9	80	25	11.92	7.00	19.55	( <sup>4</sup> )
December.....	44.2	63	25	13.51	4.95	14.93	.4
Year.....	51.3	98	8	88.99	55.53	98.76	5.4

<sup>1</sup> Average temperature for Tillamook station based on a 47-year record, through 1952; highest and lowest temperatures on a 44-year record, through 1952. At Cloverdale station, average temperature is based on an 11-year record, through 1952; highest and lowest temperatures on an 11-year record, through 1952.

<sup>2</sup> Average precipitation for Tillamook station based on a 50-year record, through 1955; wettest and driest years based on a 44-year record, in the period 1894–1955; snowfall based on a 44-year record, through 1952. At Cloverdale station, average precipitation is based on a 10-year record, through 1952; wettest and driest years based on a 10-year record in the period 1941–1952; snowfall based on a 11-year record, through 1952.

<sup>3</sup> For Tillamook station, driest year was 1911; wettest year, 1902. For Cloverdale station, driest year was 1944; wettest year, 1945.

<sup>4</sup> Trace

## Water Supply

Most of the water for domestic use and for irrigation comes directly from flowing streams or from reservoirs. In recent years several water wells have been drilled on tideland and on benchland and bottom land along rivers.

The Fairview Water District, east of Tillamook, has three reservoirs and in summer obtains additional water from wells. The city of Tillamook has two reservoirs.

A well was drilled in 1958 to provide the city with additional water in the dry season. Bay City, Nehalem, Hebo, Cloverdale, and other communities in the county obtain their water from reservoirs on live streams. Bay City also uses a well in summer. The Tillamook County Creamery Association has a reservoir on a tributary of the Kilehis River.

## Wildlife <sup>7</sup>

Tillamook County has a great diversity of habitat at elevations ranging from sea level at the coast to 3,000 feet on mountain peaks. The Oregon Coast Range occupies most of the county. Big-game animals, fur-bearing animals, rodents, fish, waterfowl, and upland birds are present in considerable variety and abundance.

Black-tailed deer are common throughout the county. Deer in the "Tillamook Burn" grow larger than average because the forage in this area is high in protein. Deer are especially common and are often troublesome on the wooded edges of valleys, where they feed on gardens.

Herds of Roosevelt elk roam the high hills and are most numerous in the northern half of the county. Black bear are plentiful, especially in wooded areas along the coast.

The most common fur bearer is the beaver. Their dams can be seen at both low and high elevations along streams. Their burrows often damage agricultural land. Otter and mink are scattered along stream valleys and near lakes.

Coyotes, cougars, bobcats, and other predators are mainly in the wooded hills. Skunks, raccoons, and weasels are common; moles and shrews are everywhere.

Numerous ground squirrels, chipmunks, and wood rats are in the county. The unique mountain beaver, actually a large gopher, makes burrows in the hills. The snowshoe rabbit is seen occasionally in the high forests; the brush rabbit is in the lowlands.

The hair seal, a predator of salmon, occurs along the coast, in bays, and along the lower courses of large streams. Herds of sea lion are often seen on offshore rocks and in the surf.

The upland game birds hunted most are the band-tailed pigeon, which is most common on certain bay shores, and the ruffed and blue grouse, which are fairly common in woods. A few ring-necked pheasants are in meadows.

Many ducks and geese use the coastal flyway. Some mallards, pintails, and wigeons spend the winter in bays and marshes. Large flocks of wigeons have damaged bay-side pastures by feeding on the grass. Extensive rafts of brant also occur on bays. A few mute swans for years have bred on coastal lakes; mergansers are common along streams.

The Three Arch Rocks Bird Refuge is the breeding area for thousands of gull, cormorant, murre, guillemot, tufted puffin, and petrel, and also for the sea lion.

The rare bald eagle, osprey, common kingfisher, night heron, and water ouzel are nongame birds. Great blue herons, cormorants, gulls, and grebes are common on bays; crows, blackbirds, gulls, robins, and song spar-

<sup>7</sup> Written by F. H. SUMNER, Oregon State game agent, Oregon State Game Commission.



rows occupy farmland; and ravens, sapsuckers, russet-backed thrushes, winter wrens, and the large pileated woodpeckers are in forests.

Three State fish hatcheries are in the county. Two of these are for salmon and one for trout. The main fish are the anadromous salmon and trout. Of the salmon, the silver and chinook are prime game fish and are sought by most fishermen. They are taken in bays by trolling herring, in tidewater by trolling spinners, and from banks by angling with lures and salmon eggs. The large sea-run steelhead trout is the target for many winter anglers along large streams. Its smaller cousin, the cutthroat, also an ocean-going trout, is taken in summer. Hatchery-reared cutthroat trout and fall-spawning rainbow trout are the fish caught most in summer.

Transplanted largemouthed black bass provide good angling in two lakes. The common salt-water and brackish-water fish caught in large numbers are flounder, surf perch, kelp greenling, sculpin, rockfish, and ling (ling-cod).

## History

Tillamook County was formed in 1853 from parts of Yamhill and Clatsop Counties and was named for the Tillamook Indian Nation.

Stories of shipwrecks and buried treasure told by descendants of shipwrecked sailors flavor the early history of the county. These stories are supported by findings of beeswax, teakwood, and chisel-marked stones. Indian stories and records of Captain Gray, Lewis and Clark, John Minto, Alexander Harvey, and other early explorers affirm this history.

Indians of the Tillamook, Nehalem, and Nestucca tribes inhabited the county. For the most part, they were friendly with the white settlers. Many seamen undoubtedly had sailed along the Tillamook coast earlier, but in 1788 Capt. Robert Gray made the first recorded landing and exploration of this part of Oregon. Four years later he discovered the Columbia River. Clark, a member of the Lewis and Clark expedition, visited the area in 1806. Other trappers and hunters passed through the area on their way up or down the coast.

The first white settler in the area known later as Tillamook County arrived in 1851. He traveled by whaleboat from Astoria and made his home in a large, hollow, dead spruce tree. Many of the other early settlers came from the Clatsop area.

Logging and sawmilling were on a small scale until in 1911. In that year a railroad was built between Portland and Tillamook and provided an outlet for both logs and lumber. A prosperous and stable dairy industry was developed at an early date. Land cleared of trees produced rich pasture for cows brought into the area.

## Population

The population of Tillamook County reached 8,810 in 1920, having doubled since 1900. The development and expansion of the dairy industry was a major influence on this growth. By 1930, the county population had increased to 11,824, mainly because of growth in the lumber industry. By 1940, 12,263 people lived in the county, but the rate of growth had slowed because many saw-

mills had closed following the forest fire in 1933. By 1950, the population had grown to 18,606. This increase from 1940 was caused mainly by expanded salvage logging of burned timber, an increase in the production of cheese, and a flourishing tourist business. According to the U.S. census, the county had a population of 18,993 in 1960.

## Community Facilities

Five high schools, which offer a 4-year curriculum, and many grade schools are in the county. The county library is in Tillamook and provides rural service through the bookmobile. Thirty-seven churches of many denominations are located in the county. The city of Tillamook alone has 14 churches. Hospitals are the Tillamook County General Hospital in Tillamook, Reinhart Memorial Hospital in Wheeler, and Bennett's Nursing Home in Tillamook.

One weekly newspaper, "The Tillamook Headlight Herald," and a local radio station, "KTIL" serve the county and are both in Tillamook. Local Granges are in ten different communities. Units of the Farm Bureau are in Tillamook and Nehalem. In addition, there are chambers of commerce and many religious, fraternal, and cultural organizations in the county.

## Recreation

The most popular recreational attractions in the county are its beaches and scenic coastline, which are readily accessible along U.S. Highway No. 101. Year-round fishing attracts many sportsmen to the hundreds of miles of streams and to the bays, lakes, sea, and surf. The county maintains boat landings and other facilities that make most recreational areas accessible to the public. In addition to fishing, clamming and crabbing are popular attractions in Nestucca, Netarts, Tillamook, and Nehalem Bays. Elk, deer, and bear attract many big-game hunters to the county.

Other popular recreational activities are beachcombing, collecting agate, and hunting for legendary treasure supposed to have been hidden by shipwrecked sailors on Neahkahnie Mountain. All recreational activities support the tourist trade, one of the county's most important economic assets. Most of the tourist trade flourishes in the period from Memorial Day through Labor Day, but weekend vacationers and sport fishermen from other parts of Oregon provide an ever increasing source of yearlong income from tourists.

## Transportation and Markets

A branch line of the Southern Pacific is the only railroad in the county. It enters the county in the northeastern corner, follows the coast south, and ends at the U.S. Naval Base about 5 miles south of Tillamook. The county is also served by the Tillamook-Portland Auto Freight, the Tillamook Mayflower Delivery Service, and by common carrier bus.

U.S. Highway No. 101 follows the coast from the north to the south end of the county. State Highways No. 22, 18, and 6 connect Tillamook County with the Willamette Valley. State Highway No. 53 runs from Mohler Junc-

tion to the north county line. Communities not on these highways are served by county roads, nearly all of which are blacktopped.

Commerce in Tillamook County depends much on trucks and highways. Large quantities of logs, lumber, hay, straw, and grain are hauled by trucks. Alfalfa and grain, which are not grown locally, are shipped in by truck as feed for dairy cattle. About 10 million pounds of cheese is manufactured in the county each year and is marketed through the Tillamook County Creamery Association. Most of the cheese is hauled to California by trucks. Several million pounds of fluid milk is produced each year and is hauled mainly to Portland by tank trucks.

A local slaughterhouse provides a market for surplus dairy cattle and other livestock. Some livestock is marketed in Portland. Poultry and eggs are produced in small quantities and are sold mainly through grocery stores. Markets are available in the county for fern, salal, and huckleberry, which are gathered for the florists' trade. Holly, Christmas trees, market vegetables, and other cool-weather crops can be produced here when markets are available.

## Agriculture

Tillamook County had 68,467 acres in 741 farms, according to the 1959 census of agriculture. About 70 percent of the farms have less than 99 acres; the average size of farm was 106 acres. About 81 percent of the farms are operated by full owners; the rest by part owners, tenants, and managers. By type, there were 445 dairy farms, 5 poultry farms, 30 livestock farms, and 261 miscellaneous farms. Most farms were commercial farms.

### *Dairying and other enterprises*

Dairying accounts for more than 86 percent of the county's annual agricultural income. Cows in the county produced an average of 330 pounds of butterfat in 1955. That year the manufacture of cheese utilized 100 million pounds of milk. Milk not made into cheese was sold as a grade A product.

Dairy farms are generally operated by one of the three following methods: (1) pasturing the herd and growing all winter roughage on the farm; (2) pasturing the herd, growing some hay and silage on the farm, and buying a good grade of alfalfa from central and eastern Oregon and Washington; (3) pasturing the herd on the entire farm and buying all winter roughage.

Most of the hay fed to dairy cattle is produced outside the county. Some operators, however, grow all their hay on improved pastures and meadows by using high-producing varieties of forage plants and by applying commercial and barnyard fertilizers. As operators grow more of their own forage, they purchase and feed less grain. An objective of the dairy industry is for operators to grow all the forage they feed to dairy cattle.

After 10 years of intensive control work, Tillamook County was declared a modified, certified, brucellosis-free area in 1955. According to the 1959 census, 545 farms reported they sold more than 122 million pounds of milk that year.

Farmers not growing hay or silage—mainly the small farms—need only a tractor, milking machine, mower, harrow, and equipment for handling liquid and solid manures. Farmers growing their own forage generally have this equipment and balers, silage cutters, blowers, forage harvesters, and other equipment for spreading lime and managing land from which forage is harvested.

The climate of Tillamook County is good for fur farms that produce ranch mink. The basic breed is natural dark mink, from which the pastel Aleutian and Sapphire mutations are raised. The production of mink is one of the county's major agricultural enterprises.

Tree farms growing Douglas-fir, spruce, and hemlock have been established on converted farm brushland. The conversion to higher use has substantially increased the value of this land. About 20,000 acres of farmland not now in crops or pasture could also be used for forest-tree farms or for the growing of holly and Christmas trees. An additional area of 8,000 acres would have agricultural potential if it were artificially drained.

## *Livestock*

According to the census of 1959, Tillamook County had 27,487 cattle and calves, nearly all of which were of dairy breeds. Nearly all milk is marketed through the Tillamook County Creamery Association, a dairy cooperative.

Besides dairy livestock, in 1959 there were 1,502 hogs and pigs in the county, 1,204 sheep and lambs, 192 mules and horses, and 12,273 chickens over 4 months old.

## *Glossary*

Definitions of technical terms are given for the convenience of readers who cannot refer to them easily elsewhere. Most of the definitions were obtained from the Soil Survey Manual (14) and are similar to those in other published works on soil science, forestry, and soil conservation.

**Aggregate (soil structure).** Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

**Allophane (mineral).** A hydrous aluminum silicate, amorphous, translucent, and of various colors.

**Available water-holding capacity.** Capacity of a soil to hold water that plants can use. Terms used in this report expressed in inches of moisture per foot of soil are—

<i>Very high.</i> —More than 12 inches	<i>Low.</i> 3 to 6 inches
<i>High.</i> —9 to 12 inches	<i>Very low.</i> —Less than 3 inches.
<i>Moderate.</i> —6 to 9 inches	

**Bedding (for drainage).** Plowing, grading, or otherwise elevating the surface of flat fields into a series of broad beds or lands separated by shallow surface drains.

**Blinding.** The practice of placing permeable material, such as sawdust, woodchips, or coarse aggregate around newly installed drainage tile to filter out sand, silt, and clay but allow water to enter the tile freely.

**Clay.** As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

**Colluvium.** Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the bases of steep slopes. In this area it includes material distributed on the slopes from the top to the bottom.

**Consistence, soil.** The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

*Cemented.* Hard and brittle; little affected by moistening.

*Firm.* When moist, crushes under moderate pressure between thumb and forefinger and can be pressed together into a lump.

*Friable.* When moist, crushes easily under gentle to moderate pressure between thumb and forefinger and can be pressed together into a lump.

*Hard.* When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

*Loose.* Noncoherent; will not hold together in a mass.

*Plastic.* When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a wire when rolled between thumb and forefinger.

*Soft.* When dry, breaks into powder or individual grains under very slight pressure.

*Sticky.* When wet, adheres to other material; tends to stretch somewhat and pull apart, rather than pull free from other material.

**Diameter breast high.** The diameter of a tree 4.5 feet above the average ground level. Abbreviated, dbh.

**Drainage, surface.** Runoff, or surface flow, of water from an area.

**Erosion hazard.** The estimated risk of erosion if a soil is left bare for long periods. Relative classes are *none*, *slight*, *moderate*, *high*, and *very high*.

**Fertility, soil.** The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors, such as light, moisture, temperature, and the physical condition (or tilth) of the soil are favorable. As used in this report, fertility refers to the ability of a soil to provide nutrients for grass legume crops. Five classes of soil fertility are used: *High*, *moderately high*, *medium*, *moderately low*, and *low*. Compared to soils outside the Tillamook survey area, all the soils in the survey area are low to very low in fertility.

**Flood plain.** Nearly level land, consisting of stream sediment, that borders a stream and is subject to flooding unless protected artificially.

**Genesis, soil.** The manner in which the soil originated, with special reference to the processes responsible for the development of the solum, or true soil, from the unconsolidated parent material.

**Granular.** See Structure, soil.

**Horizon, soil.** A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. The relative position of the several soil horizons in a typical soil profile, and their nomenclature, are as follows:

A0 Organic debris, partly decomposed or matted.

A1 A dark-colored horizon having a fairly high content of organic matter mixed with mineral matter.

A2 A light-colored horizon, often representing the zone of maximum leaching where podzolized; absent in wet, dark-colored soils.

A3 Transitional to B horizon but more like A than B; sometimes absent.

B1 Transitional to B horizon but more like B than A; sometimes absent.

B2 A usually darker colored horizon, which often represents the zone of maximum illuviation where podzolized.

B3 Transitional to C horizon.

C Slightly weathered parent material; absent in some soils.

D Any stratum underlying the C, or the B if no C is present, which is unlike the C, or unlike the material from which the solum has been formed.

The A horizons make up a zone of eluviation, or leached zone. The B horizons make up a zone of illuviation, in which clay and other materials have accumulated. The A and B horizons, taken together, are called the solum, or true soil.

**Massive.** See Structure, soil.

**Mottled.** Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few*, *common*, and *many*; size—*fine*,

*medium*, and *coarse*; and contrast—*faint*, *distinct*, and *prominent*. The size measurements are: *fine*, less than 5 mm. (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 mm. to 15 mm. (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 mm. (about 0.6 inch) in diameter along the greatest dimension.

**Nutrient, plant.** Any element taken in by a plant, essential to its growth, and used by it in the production of food and tissue. Nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, zinc, and perhaps other elements obtained from the soil and carbon, hydrogen, and oxygen obtained largely from the air and water, are plant nutrients.

**Open drain.** A ditch constructed to remove surplus water from wet land; may also include cross-slope ditches on sloping land.

**Pasture.** Areas in which livestock is pastured because the soil is steep, shallow, or poorly drained, or because stumps, trees, and other factors prevent using the land for tillage.

**Ped.** An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

**Permeability, soil.** The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *Very slow*, *slow*, *moderately slow*, *moderate*, *moderately rapid*, *rapid*, and *very rapid*.

**Profile, soil.** A vertical section of the soil through all its horizons and extending into the parent material. See Horizon, soil.

**Reaction, soil.** The degree of acidity or alkalinity of a soil expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction, because it is neither acid nor alkaline. In words the degree of acidity or alkalinity is expressed thus:

	pH		pH
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

**Residuum.** Unconsolidated, partly weathered mineral material that accumulates over disintegrated solid rock. Residual material is not soil but is frequently the material in which a soil is formed.

**Rotation grazing.** Grazing in two or more areas in regular order, with definite recovery periods between grazing periods. Contrasts with continuous grazing.

**Runoff.** Refers to the amount of water removed by flow over the surface of the soil. The amount and rapidity of runoff are affected by factors such as texture, structure, and porosity of the surface soil; the vegetative covering; the prevailing climate; and the slope. The degree of runoff is expressed by the terms: *Very rapid*, *rapid*, *medium*, *slow*, *very slow*, and *pounded*.

**Sand.** Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 mm. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

**Scribner rule.** A rule for determining the board-foot content of a log. The Scribner decimal C log rule drops the units and gives the contents of a log to the nearest 10 board feet.

**Sedimentary rock.** A rock composed of particles deposited from suspension in water. The chief sedimentary rocks are conglomerate, from gravel; sandstone, from sand; shale, from clay; and limestone, from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sands have been consolidated into sandstone.

**Silt.** Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 mm.) to the lower limit of very fine sand (0.05 mm.). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

**Single grain.** See Structure, soil.

**Site index (forestry).** A numerical means of expressing the quality of a forest site, based on the height of the dominant stand at an arbitrarily chosen age; for example, the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years.

**Skid.** To pull logs from the stump to the skidway, landing, or mill.

**Slash.** Debris left after logging, pruning, thinning, or brush cutting; or large accumulations of debris after a wind or fire.

**Slope, percent.** The difference in elevation for each 100 feet of horizontal distance. Each slope group in this report has a definite nomenclature. Slope terms used are—

0 to 3 percent	nearly level
3 to 7 percent	gently sloping
7 to 12 percent	strongly sloping
12 to 20 percent	moderately steep
20 to 40 percent	steep
40+ percent	very steep

**Smoothing.** Reshaping land surface to make it suitable for cultivation.

**Snag.** A standing dead tree from which the leaves and most of the branches have fallen; or a standing section of the stem of a tree broken off at a height of 20 feet or more.

**Soil depth.** Refers to depth of the soil profile. Classes of soil depth are: *Shallow*, 10 to 20 inches; *moderately deep*, 20 to 36 inches; *deep*, 36 to 60 inches; and *very deep*, 60 inches +.

**Solum.** The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying parent material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

**Spoil-bank leveling.** Spreading of material taken from a ditch or canal over adjacent land.

**Stocking.** The degree to which an area is effectively covered with living trees. Fully stocked or normal stands contain as many trees per acre as can properly utilize the growing space available.

**Structure, soil.** The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are *platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal) *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

**Subsoil.** Technically the B horizon; roughly, the part of the profile below plow depth.

**Substratum.** Any layer lying beneath the solum, or true soil; the C or D horizon.

**Texture, soil.** The relative proportions of sand, silt, and clay particles in a mass of soil. (See also Clay, Sand, and Silt.) The basic textural classes, in order of increasing proportions of fine particles are as follows: *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

**Tide gate.** The opening through which water may flow freely when the tide sets in one direction, but which closes automatically and prevents the water from flowing in the other direction.

**Topsoil.** A presumed fertile soil or soil material, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

**Tolerance.** The capacity of a tree to develop and grow in the shade of and in competition with other trees.

**Tussock.** A dense tuft of marshgrass or sedge in a wet meadow or bog.

**Upland.** Land consisting of material unworked by water in recent geologic time and lying, in general, at a higher elevation

than the alluvial plain or stream terrace. Land above the lowlands along rivers.

**Water table.** The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from the lower one by a dry zone.

**Yarding.** Gathering material at a central point on a yard or skidway. Generally used in connection with high-lead logging.

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## GUIDE TO MAPPING UNITS, CAPABILITY UNITS, AND WOODLAND SUITABILITY GROUPS

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			Symbol	Page	Number	Page
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AsF	Astoria silt loam, 20 to 40 percent slopes.....	37	VIc-1	16	8	25
AsG	Astoria silt loam, 40 to 60 percent slopes.....	37	VIIc-1	17	9	25
AtF	Astoria silt loam, moderately deep, 20 to 40 percent slopes.....	38	VIc-1	16	8	25
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GmB	Gauldy loam, 0 to 7 percent slopes.....	43	IIc-1	11	1	21
GsB	Gauldy loam, shallow, 0 to 7 percent slopes.....	43	VIc-1	17	17	28
GtB	Ginger silt loam, 0 to 7 percent slopes.....	43	IIw-1	10	5	24
HbA	Hebo silty clay loam, 0 to 3 percent slopes.....	44	IVw-2	15	5	24
HeC	Hembre silt loam, 3 to 12 percent slopes.....	46	IIIc-1	12	10	25
HeD	Hembre silt loam, 12 to 20 percent slopes.....	46	IVe-1	13	10	25
HeF	Hembre silt loam, 20 to 40 percent slopes.....	45	VIc-2	17	11	26
HeG	Hembre silt loam, 40 to 60 percent slopes.....	45	VIIc-2	17	12	27
HmF	Hembre silt loam, moderately deep, 20 to 40 percent slopes.....	46	VIc-2	17	11	26
HmG	Hembre silt loam, moderately deep, 40 to 60 percent slopes.....	46	VIIc-2	17	12	27
KaB	Knappa silt loam, 0 to 7 percent slopes.....	46	IIc-1	10	3	24
KaC	Knappa silt loam, 7 to 12 percent slopes.....	46	IIIc-1	12	3	24
KmC	Knappa silt loam, moderately deep, 0 to 12 percent slopes.....	46	IIIc-1	12	3	24
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NeB	Nehalem silt loam, overwashed, 3 to 7 percent slopes.....	48	IVe-2	14	17	28
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NkF	Neskowin silty clay loam, 20 to 40 percent slopes.....	48	VIc-3	17	14	28
NkG	Neskowin silty clay loam, 40 to 60 percent slopes.....	48	VIIc-3	17	15	28
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NtE	Netarts fine sandy loam, 7 to 30 percent slopes.....	49	VIIc-4	18	16	28
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WeF	Winema silt loam, 20 to 40 percent slopes.....	51	VIc-3	17	8	25
WmD	Winema silt loam, moderately deep, 12 to 20 percent slopes.....	51	IVe-1	13	7	25
WmF	Winema silt loam, moderately deep, 20 to 40 percent slopes.....	51	VIc-3	17	8	25
YaA	Yaquina loamy fine sand, 0 to 3 percent slopes.....	51	IIIw-3	13	6	24



# Accessibility Statement

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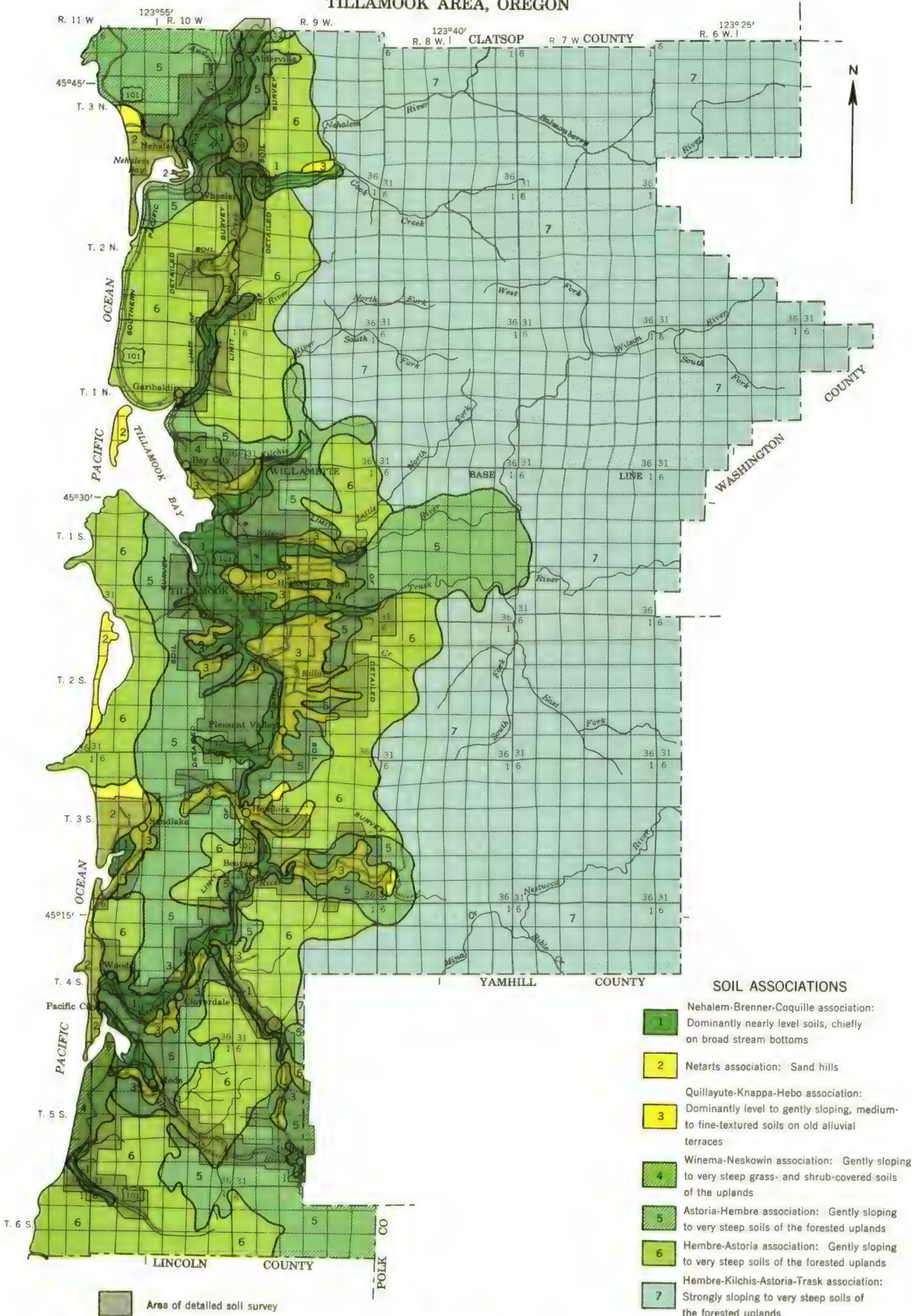
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# GENERAL SOIL MAP TILLAMOOK AREA, OREGON

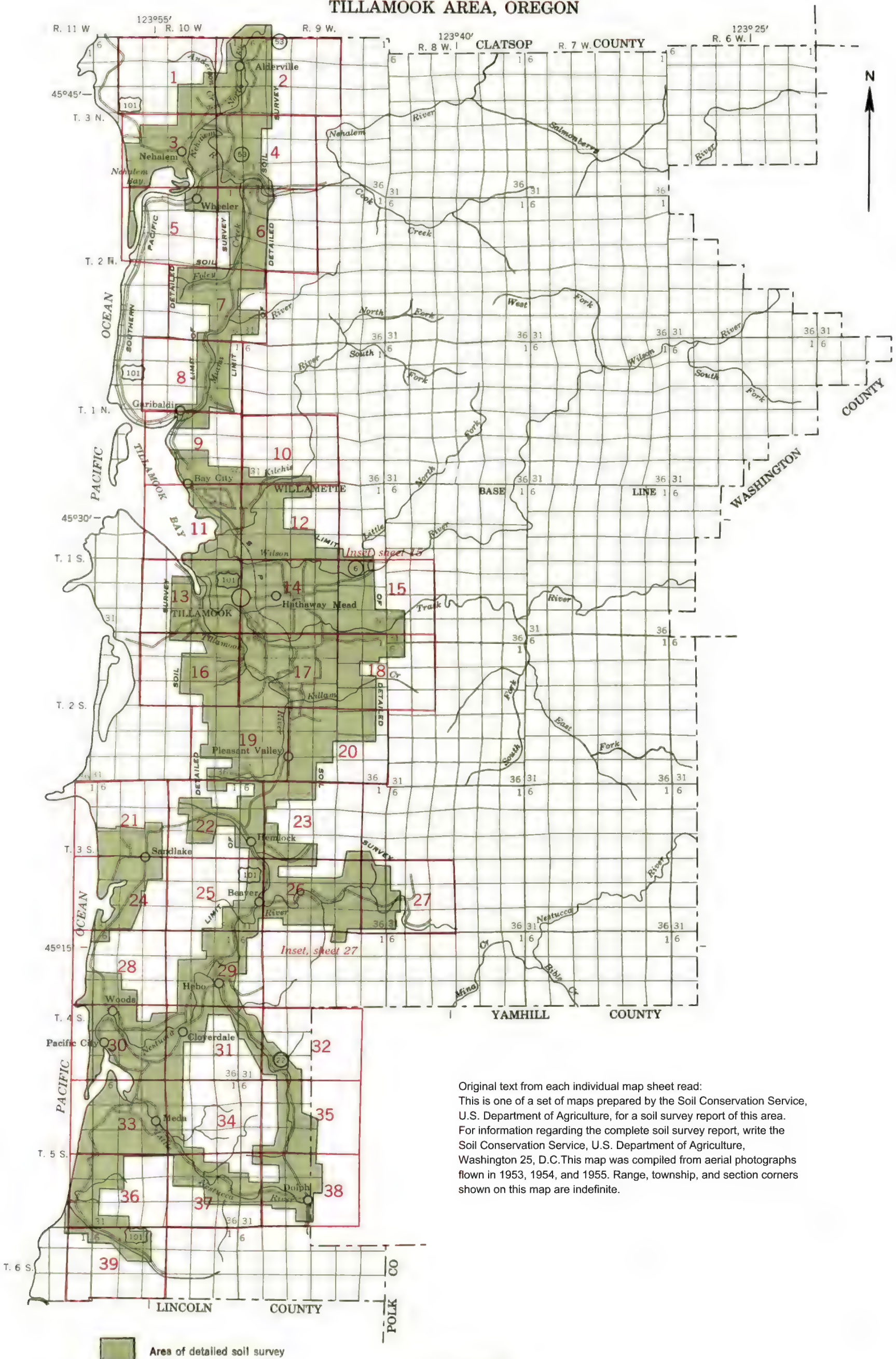


## SOIL ASSOCIATIONS

- 1** Nehalem-Brenner-Coquille association: Dominantly nearly level soils, chiefly on broad stream bottoms
- 2** Netarts association: Sand hills
- 3** Quillayute-Knapka-Hebo association: Dominantly level to gently sloping, medium- to fine-textured soils on old alluvial terraces
- 4** Winema-Neskowin association: Gently sloping to very steep grass- and shrub-covered soils of the uplands
- 5** Astoria-Hembre association: Gently sloping to very steep soils of the forested uplands
- 6** Hembre-Astoria association: Gently sloping to very steep soils of the forested uplands
- 7** Hembre-Kilchis-Astoria-Trask association: Strongly sloping to very steep soils of the forested uplands



# INDEX TO MAP SHEETS TILLAMOOK AREA, OREGON



Original text from each individual map sheet read:  
This is one of a set of maps prepared by the Soil Conservation Service, U.S. Department of Agriculture, for a soil survey report of this area. For information regarding the complete soil survey report, write the Soil Conservation Service, U.S. Department of Agriculture, Washington 25, D.C. This map was compiled from aerial photographs flown in 1953, 1954, and 1955. Range, township, and section corners shown on this map are indefinite.



SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, E, F, or G, shows the slope. Symbols without a slope letter are those of nearly level soils, such as Brenner silt loam, or of land types, such as Rock land, that have a considerable range of slope.

SYMBOL	NAME
Ad	Active dune land
AsC	Astoria silt loam, 3 to 12 percent slopes
AsD	Astoria silt loam, 12 to 20 percent slopes
AsF	Astoria silt loam, 20 to 40 percent slopes
AsG	Astoria silt loam, 40 to 60 percent slopes
AtF	Astoria silt loam, moderately deep, 20 to 40 percent slopes
AtG	Astoria silt loam, moderately deep, 40 to 60 percent slopes
Bp	Brallier peat
Br	Brenner silt loam
ChB	Chitwood silt loam, 0 to 7 percent slopes
ChC	Chitwood silt loam, 7 to 12 percent slopes
Co	Coquille and Brenner silt loams
GaA	Gardiner fine sandy loam, 0 to 3 percent slopes
GdB	Gardiner fine sandy loam, overwashed, 3 to 7 percent slopes
GmB	Gauldy loam, 0 to 7 percent slopes
GsB	Gauldy loam, shallow, 0 to 7 percent slopes
GtB	Ginger silt loam, 0 to 7 percent slopes
HbA	Hebo silty clay loam, 0 to 3 percent slopes
HeC	Hembre silt loam, 3 to 12 percent slopes
HeD	Hembre silt loam, 12 to 20 percent slopes
HeF	Hembre silt loam, 20 to 40 percent slopes
HeG	Hembre silt loam, 40 to 60 percent slopes
HmF	Hembre silt loam, moderately deep, 20 to 40 percent slopes
HmG	Hembre silt loam, moderately deep, 40 to 60 percent slopes
KaB	Knappa silt loam, 0 to 7 percent slopes
KaC	Knappa silt loam, 7 to 12 percent slopes
KmC	Knappa silt loam, moderately deep, 0 to 12 percent slopes
Ma	Made land
MeC	Meda gravelly loam, 3 to 12 percent slopes
MeD	Meda gravelly loam, 12 to 20 percent slopes
NaA	Nehalem silt loam, 0 to 3 percent slopes
NeB	Nehalem silt loam, overwashed, 3 to 7 percent slopes
NkD	Neskowin silty clay loam, 12 to 20 percent slopes
NkF	Neskowin silty clay loam, 20 to 40 percent slopes
NkG	Neskowin silty clay loam, 40 to 60 percent slopes
Ns	Nestucca silt loam
NtE	Netarts fine sandy loam, 7 to 30 percent slopes
QaB	Quillayute silt loam, 0 to 7 percent slopes
QmC	Quillayute silt loam, moderately deep, 0 to 12 percent slopes
Re	Riverwash
Ro	Rock land
Tf	Tidal flats
WeC	Winema silt loam, 3 to 12 percent slopes
WeD	Winema silt loam, 12 to 20 percent slopes
WeF	Winema silt loam, 20 to 40 percent slopes
WmD	Winema silt loam, moderately deep, 12 to 20 percent slopes
WmF	Winema silt loam, moderately deep, 20 to 40 percent slopes
YaA	Yaquina loamy fine sand, 0 to 3 percent slopes

WORKS AND STRUCTURES

Highways and roads	
Dual	
Good motor	
Poor motor	
Trail	
Highway markers	
National Interstate	
U. S.	
State	
Railroads	
Single track	
Multiple track	
Abandoned	
Bridges and crossings	
Road	
Trail, foot	
Railroad	
Ferries	
Ford	
Grade	
R. R. over	
R. R. under	
Tunnel	
Buildings	
School	
Church	
Station	
Mines and Quarries	
Mine dump	
Pits, gravel or other	
Power lines	
Pipe lines	
Cemeteries	
Dams	
Levees	
Tanks	
Oil wells	
Sawmill	

CONVENTIONAL SIGNS

BOUNDARIES	
National or state	
County	
Township, U. S.	
Section line, corner	
Reservation	
Land grant	

DRAINAGE

Streams	
Perennial	
Intermittent, unclass.	
Canals and ditches	
Lakes and ponds	
Perennial	
Intermittent	
Wells	
Springs	
Marsh	
Wet spot	

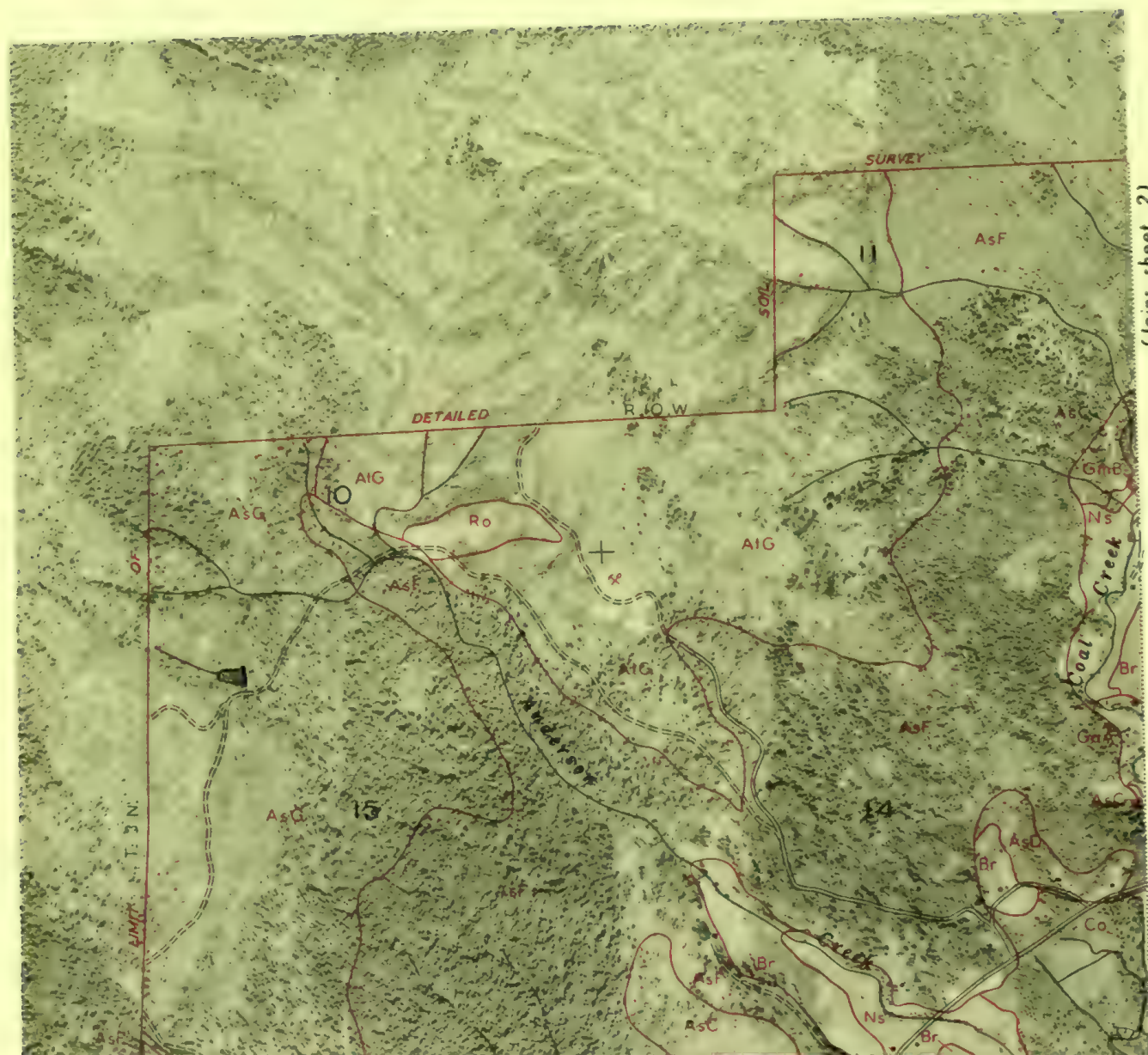
RELIEF

Escarpments	
Bedrock	
Other	
Prominent peaks	
Depressions	
Crossable with tillage implements	
Not crossable with tillage implements	
Contains water most of the time	

SOIL SURVEY DATA

Soil boundary and symbol	
Gravel	
Stones	
Rock outcrops	
Chert fragments	
Clay spot	
Sand spot	
Gumbo or scabby spot	
Made land	
Severely eroded spot	
Blowout, wind erosion	
Gullies	

Soil map constructed 1963 by Cartographic Division, Soil Conservation Service, USDA, from 1953, '54, and '55 aerial photographs. Controlled mosaic based on Oregon plane coordinate system, north zone, Lambert conformal conic projection. 1927 North American datum.



(Joins sheet 3)





# TILLAMOOK AREA, OREGON—SHEET NUMBER 11

R.O.W.

(Join sheet 9)

TILLAMOOK

BAY



# TILLAMOOK AREA, OREGON - SHEET NUMBER 12

12

(Joins sheet 10)

R.O.W.

LINE

N

(Joins sheet 11)



(Joins sheet 14)

(Joins sheet 13)



# TILLAMOOK AREA, OREGON—SHEET NUMBER 14

14



(Joins sheet 12)

(Joins sheet 13)

(Joins sheet 15)



(Joins sheet 17)





(Joins inset)

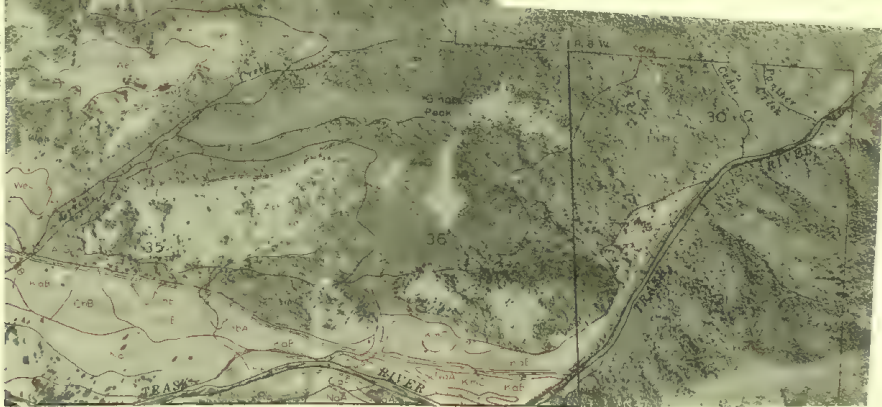


(Joins sheet 12)



(Joins left above)

(Joins sheet 14)



(Joins sheet 18)

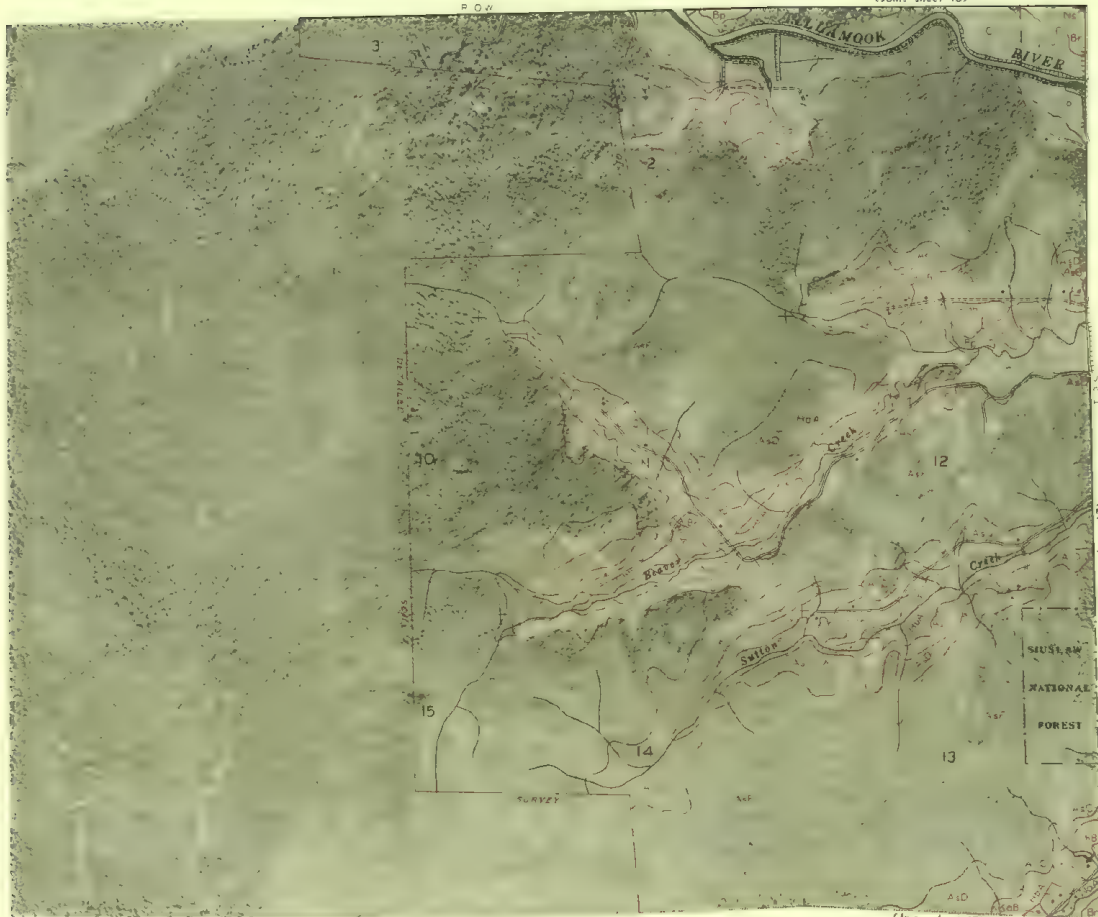
0 1/2 1 Mile Scale 1:20 000 0 5000 Feet

(Join sheet 13)

P. O. R.

16

N



(Join sheet 19)

0 1/2 1M e Scale 1:20 000 0 5000 Feet

(Joins sheet 14)

17



(Joins sheet 18)

(Joins sheet 16)



(Joins sheet 19) (Joins sheet 20)

0

2

1 Mile

Scale 1:20 000

0

5000 Feet

(Joins sheet 15)

18



(Joins sheet 20)

0 1/2 1 1/2 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

Scale 1"=20,000'

5000 Feet











20

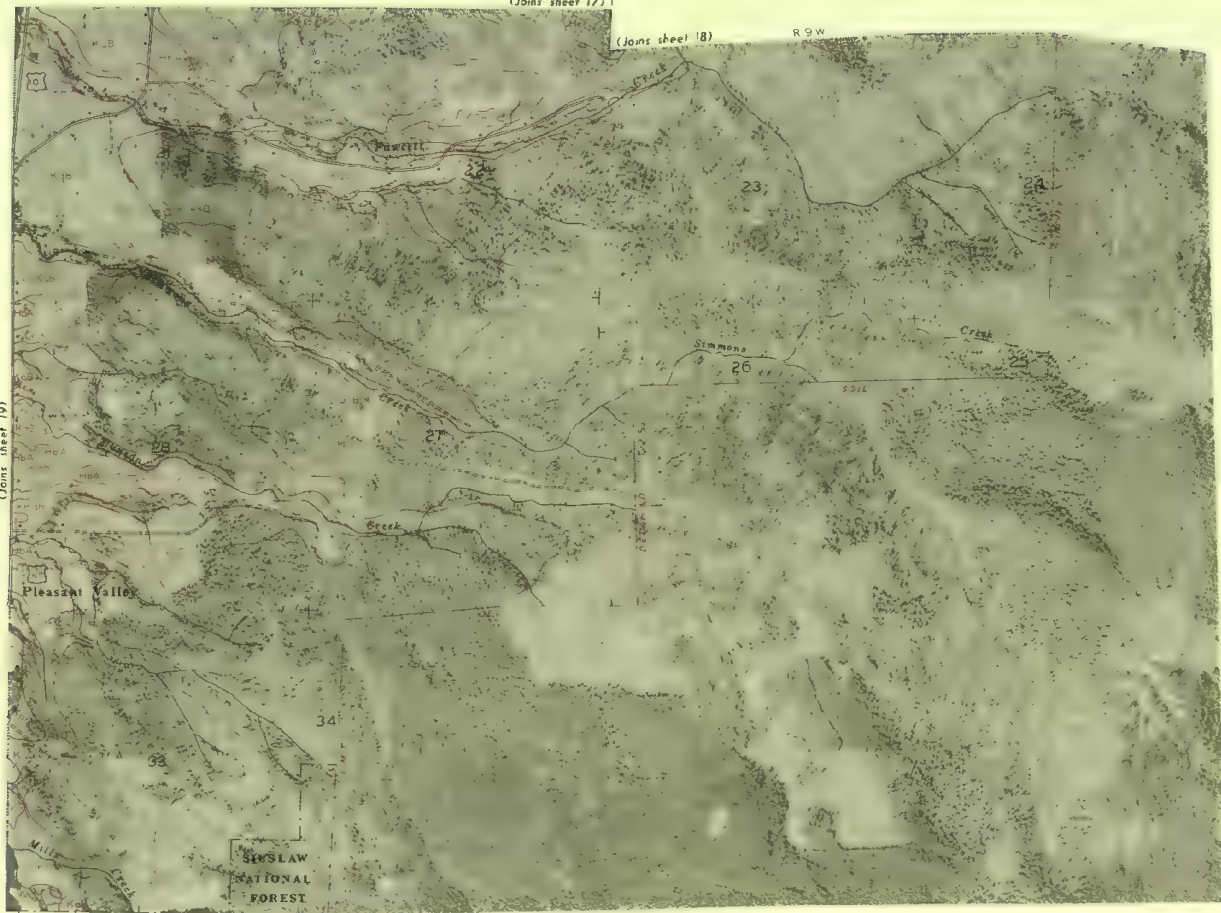
N  
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(Joins sheet 19)

(Joins sheet 17)

(Joins sheet 18)

R 9 W



(Joins sheet 23)

0 1/2 1 Mile Scale 1:20 000 0 5000 Feet



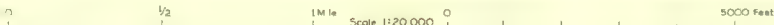
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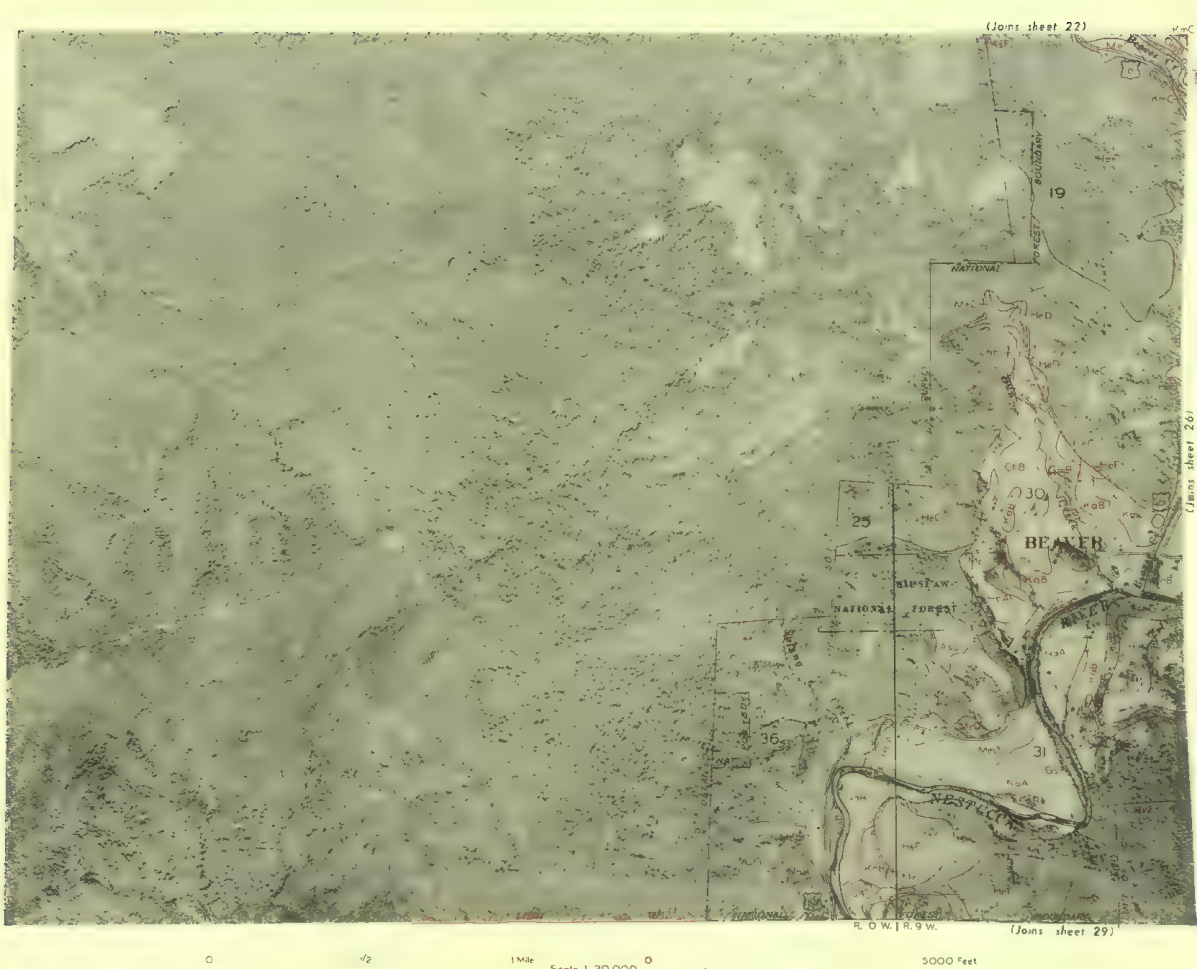
(Join sheet 24)  
5000 Feet



22







(Joins sheet 23)

(Joins sheet 25)



(Joins inset, sheet 27)

0 1/2 1 mile Scale 1:20 000 0

5000 Feet





(Jains sheet 26)



28



0 1/2 1 Mile Scale 1:20 000 0 5000 Feet





R. I. C. W.

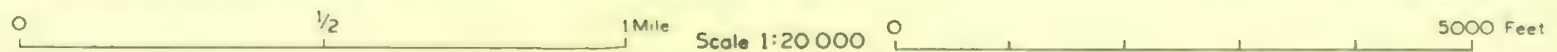
(Joins sheet 1)

3



(Joins sheet 4)

(Joins sheet 5)





R.I.W. R.C.W. (Joins sheet 28)

PACIFIC OCEAN

24

Beach

Ad

25

K. W. O. G. A.

36

North

SUSLAW  
NATIONAL  
FOREST

Sp 1

Pacific City

LANDING  
STRIP

NESTUCCA

NESTUCCA

BAY

Brooken  
MountainNESTUCCA  
RIVER

Horn

Alderman  
Butte

(Joins sheet 33)

(Joins sheet 31)

0

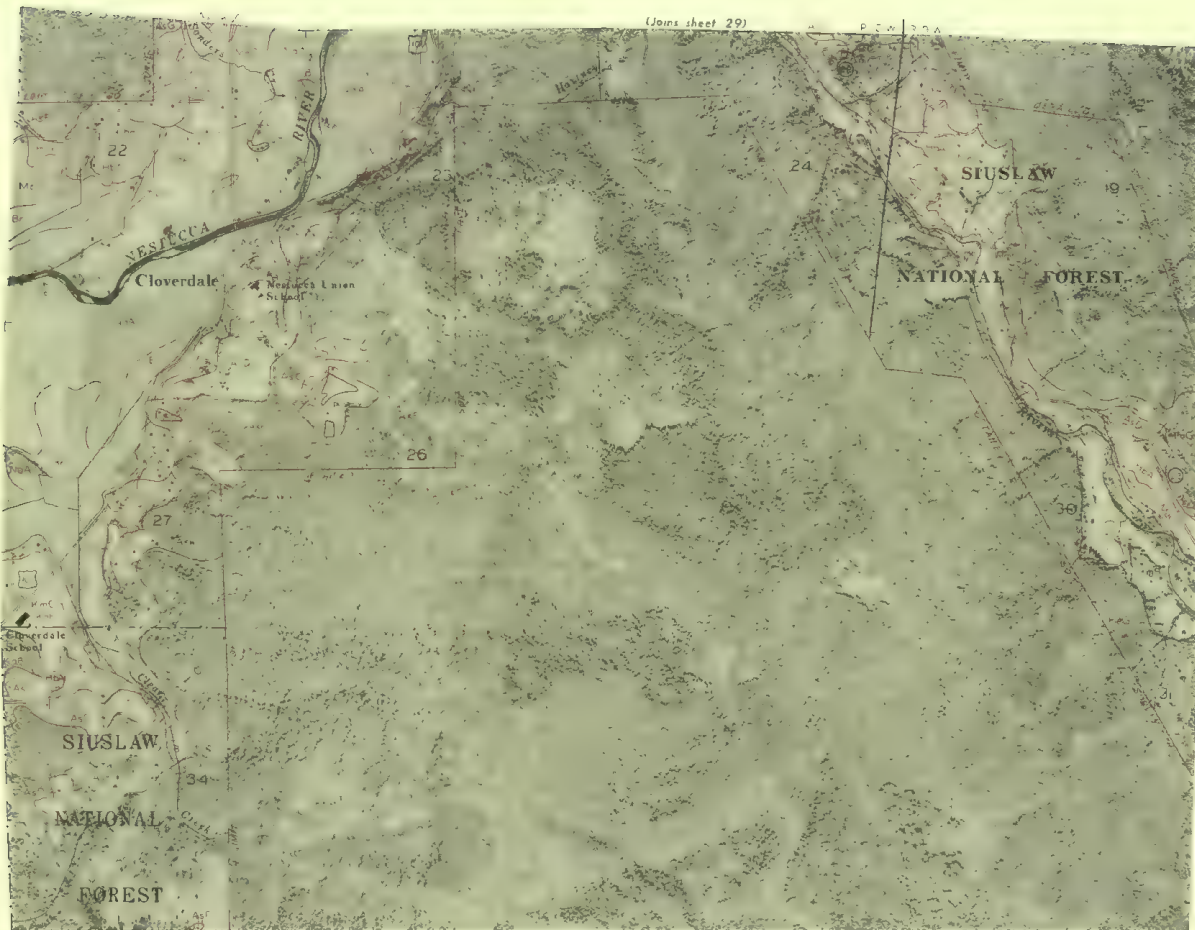
1/2

1 Mile

Scale 1:20 000

0

5000 Feet



(Joins sheet 34,

1 Mile Scale 1" = 20,000'

5000 Feet



TILLAMOOK COUNTY  
YAMHILL COUNTY

YAMHILL  
TILLAMOOK

COUNTY  
COUNTY

5

2

384

Scale 1:20 000

5000 Feet





(34)

(Joins sheet 31)

STUSLAW

NATIONAL FOREST

SIUSLAW.

# NATIONAL FOREST

STU SEAW

NATIONALE

SIUŚLAW

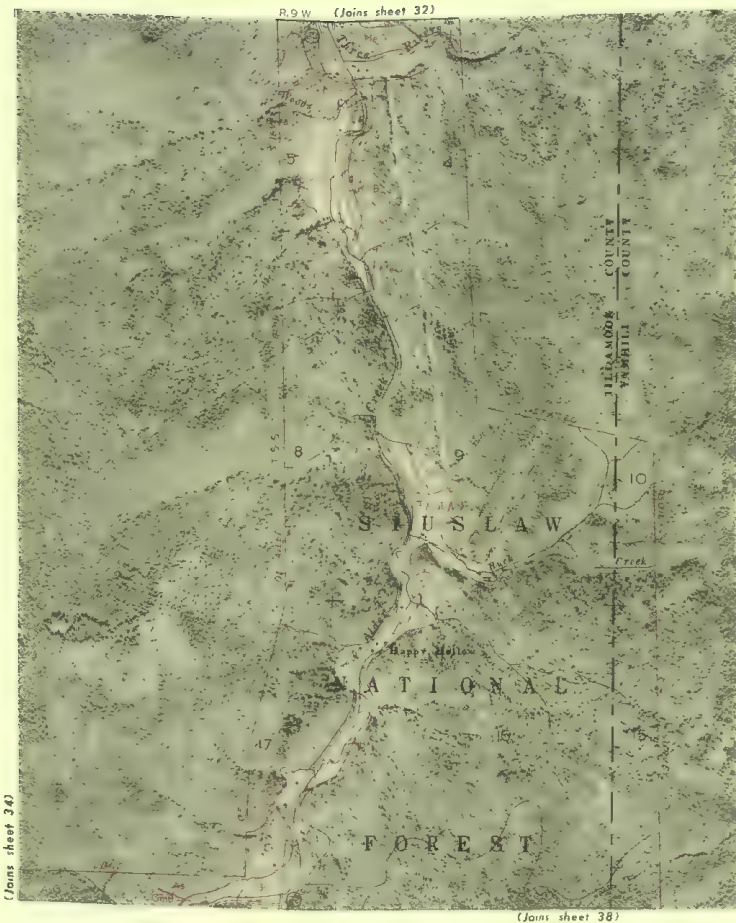
NATIONAL FOREST

R. O. N. | R 9 W

(Jones sheet 37)

0 1/2 1 Mile Scale 1:20,000 0 5000 Feet

(Jones sheep 35)



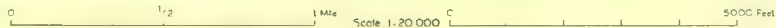
(Joins sheet 38)

Scale 1:20000

5000 Feet



(Joins sheet 39)



(Joins sheet 34)

37

N

(Joins sheet 38)

SIUSLAW NATIONAL FOREST

C 2

1 Mile

Scale 1:20,000

5000 Feet



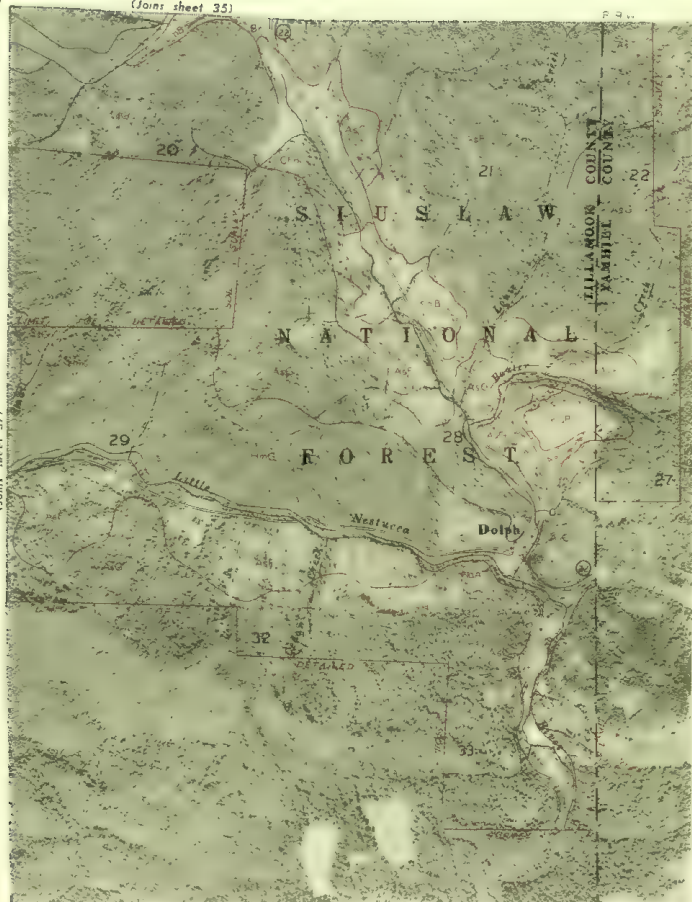
38

(Joint sheet 35)

P. 3. 1.

N

Cont. sheet 37



1/2

Mile

Scale 1:20 000

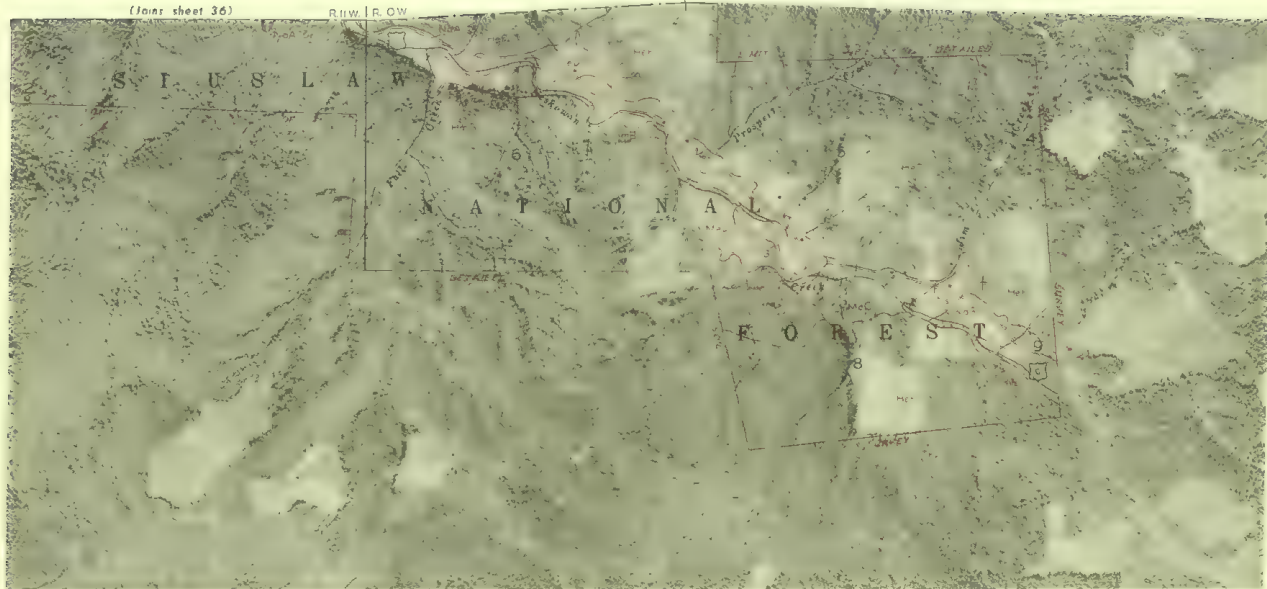
5 000 Feet

(Join sheet 36)

R.W. ROW

39

N



0

1/2

1 Mile

Scale 1:20 000

0

5000 Feet



(Joins sheet 2)

R. 10 W. | R. 9 W.

4

(Joins sheet 3)

LIMIT

OF

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—

DETAILED

5014

**SURVEY**

(Joins sheet 6)

○

 $\frac{1}{2}$ 

1 Mile

Scale 1:20 000

○

5000 Feet



R.I.O.W.

(Joins sheet 3)

5



(Joins sheet 6)



⑥

7  
↑

(Joins sheet 5)

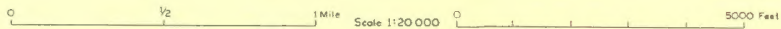


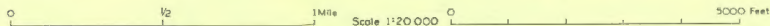
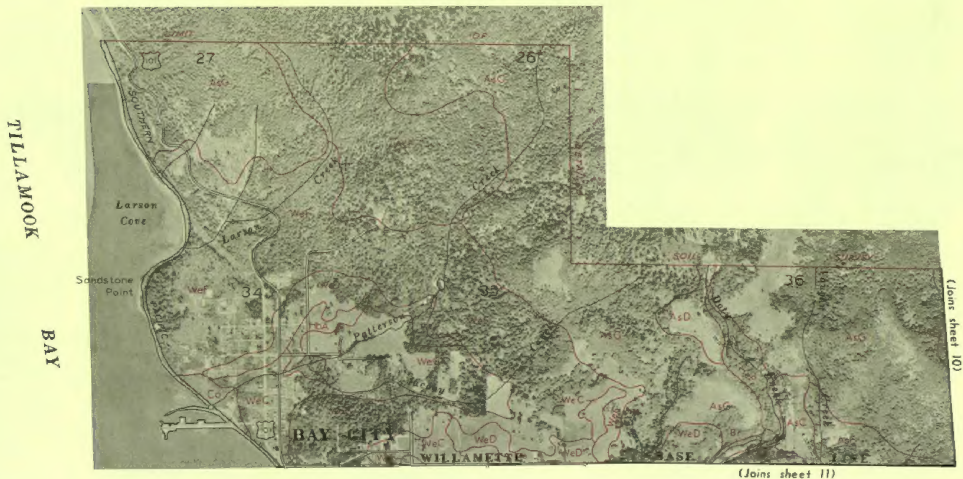
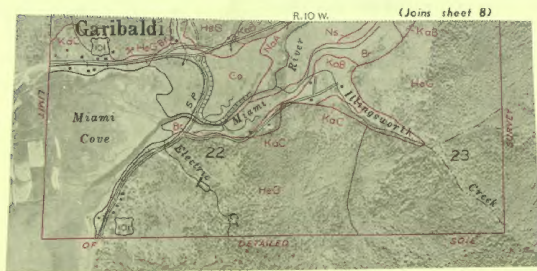






(Joins sheet 9)









T. 3 S.

(Joins sheet 22)

(Joins sheet 27)

(Joins sheet 26)

0 1/2 1 Mile Scale 1:20 000 0 5000 Feet

